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(*Recognosce notum, ignotum inspice*)

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J. RAMSBOTTOM, B. BARNES and H. WORMALD

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VOLUME XXIII JULY 1939 No. 2

NOTES ON ENTOMOGENOUS FUNGI

BY T. PETCH

(With 8 Text-figures)

135. *ENTOMOPHTHORA RETICULATA* Petch, n.sp.

WHEN searching for entomogenous fungi among moss on a cliff face at Ingleborough, Yorks, in September 1934, I found a dipterous pupa, which broke when handled and disclosed a pale reddish, granular mass of spores. Other similar pupae gathered in close proximity were healthy. The spores are spherical, 44–84 μ diameter, and each is a spherical, yellow, thick-walled cell, 34–72 μ diameter, with a wall, 3 μ thick, reticulated with a wide-meshed network of narrow ridges which form a border, 5 μ wide, to the spore. The spore is at first enclosed in a thin-walled cell, from which it may be liberated by pressure. The fungus appears to be an *Entomophthora* (*Tarichium*), though the spore differs from anything previously described in that genus.

Fig. 1. *Entomophthora reticulata*, zygospore, × 250.

Fig. 2. *Entomophthora bullata*, zygospores, × 250.

In 1935, Dr A. H. W. Povah published *E. bullata* Thaxt., n.sp. ined., found on "blue bottle" flies on the tips of grasses on Isle Royale, Lake Superior, which has bullate zygospores, 33–50 μ diameter. Dr Povah has kindly furnished me with a drawing of these zygospores, from which it appears that they have an outer cellular coat, the outer walls of the cells bulging outwards. As the spore increases in size, these cells separate, and become single protuberances on the spore. It would appear that the spore is at first enclosed in a coat of fused hyphae, which subsequently splits into separate cells.

Entomophthora (*Tarichium*) *reticulata* Petch, sp.n. Zygosporis sphaericis, 44–84 μ diam., pariete 3 μ crasso, flavo vel pallide brunneo, costis altis angustis late reticulatis, margine 5 μ lato. In pupa dipteri, Britannia.

not an Entomophthora

136. The resting spores of *Entomophthora Aphidis* Hoffm.

The description of *Entomophthora Aphidis* was published in Fresenius, "Ueber die Pilzgattung Entomophthora" (*Abh. Senkenb. naturf. Ges.* II (1858), 201. Hoffmann found only the resting spores, and hence the fungus was transferred to the genus *Tarichium* by Cohn (*Beitr. Biol. Pfl.* I (1875), 84). It occurred in an aphis on leaves of *Cornus sanguinea*. The resting spores completely filled the body of the insect, making it irregularly nodular, and were 33–43 μ, generally 37–40 μ in diameter. The accompanying hyphae were said to be brown, but the colour of the resting spores was not given.

Entomophthora Aphidis was found again by Winter and recorded by him in *Bot. Zbl.* V (1881), and redescribed in *Rabh. Krypt. Flora*, I (1883), 78. It occurred on an aphis on *Cornus sanguinea* in September and October, the individuals which contained the resting spores being black, shrivelled and mummified. The conidia measured 26–30 × 10–16 μ, and the resting spores 33–43 μ in diameter. The latter were brownish when young, but hyaline when mature. The measurement of the resting spores would appear to have been taken from Fresenius's account.

Thaxter redescribed *Entomophthora Aphidis* in his *Entomophthoreae of the United States* (1888). He stated that the conidia were noticeable for their considerable range of variation both in size and shape, and gave the average measurement as 25 × 12 μ, with a maximum 40 × 16 μ. Though he found the species common in the United States, he did not observe the resting spores. An interesting feature of the fungus is "the production, from a central cell with highly refractive contents, of a mass of hyphae growing from it in all directions, and subsequently giving rise to the conidiophores" (Thaxter). He did not give the dimensions of the central cell, but from his figure it would appear to be about 40 μ diameter. In view of Fresenius's remarks on the difficulty of separating the resting spores from the hyphae, as compared with their easy separation in other species, there would seem to be a possibility that what Fresenius saw were not resting spores, but the "central cells" in the early stages of development of the masses of hyphae.

In September 1937, Mr Norman C. Preston gave me specimens of an *Entomophthora* on the root aphis, *Pemphigus lactucarius*, on lettuce, and I am indebted to him and to Mr H. C. F. Newton for further consignments in October of the same year. The affected insects were lying free in the soil, generally in contact with the roots of the plant, and in nearly all the abdomen had been converted into a white, rather fragile mass of resting spores, the body wall having disappeared. These resting spores were spherical, smooth, hyaline, very thick-walled, 23–32 μ in diameter. Only one specimen bore conidia,

and these agreed in shape with those of *Entomophthora Aphidis*, but measured only 12–18 × 9–12 μ. I have, however, examined a specimen of *E. Aphidis*, typical as regards shape of conidia, cystidia and rhizoids, in which the conidia measured 14–23 × 10–13 μ, and there seems little doubt that the fungus on the root aphis is that species.

It would appear that either the original description of the mode of occurrence and the dimensions of the resting spores of *E. Aphidis* requires extension, or that the bodies observed by Fresenius were not resting spores.

137. *Entomophthora occidentalis* Thaxter

This species was described by Thaxter from American specimens on aphids, always on White Birch (*Betula populifolia*). Its conidia resemble those of *Entomophthora sphaerosperma*, but are much longer. A single example was found on an aphid on sycamore in Millington Wood, near Pocklington, Yorks, in September 1937, the first recorded occurrence in this country. The conidia (from a spore print) measured 30–45 × 8–9 μ.

138. *Empusa Grylli* (Fres.) Nowak.

A single example of this species was found on Allerthorpe Common, Yorks, August 1936, on a grasshopper on a stem of *Juncus*, the first recorded occurrence in this country. Search was made in the same locality in September 1937, but without success. The weather on the latter occasion was very dry, but nevertheless several specimens of *Empusa Muscae* on flies on grasses were found.

139. *Torrubiella aranicida* Boud.

Specimens of this species were found at Hubberholme, Yorks, in September 1936, on spiders under the free lower edge of sheets of moss on a cliff face. The perithecia were hyaline when fresh, and became amber-coloured on drying. It had not been recorded previously for Great Britain.

140. *Cordyceps polyarthra* Möller

A note on this species (note 54), dealing chiefly with the synonymy of the perithecial and conidial stages, was published in *Trans. Brit. Mycol. Soc.* xviii (1933), 52. Recently I have examined further specimens, collected by C. W. Dodge and Goerger in Costa Rica, 25 July 1936. Möller's specimen and others previously examined were on large sphingid pupae enclosed in dead leaves. The recent examples were on much smaller pupae, about 2 cm. long, enclosed in dead leaves, the space between the leaves and the pupa being filled with

loose white mycelium. The clavae emerged through the leaf, with a more or less circular patch of mycelium spreading over the leaf from the base of the clava, as though it was growing on the leaf.

In Möller's specimen the pupa bore over a dozen clavae of varying lengths up to 5·5 cm., but scarcely 1 mm. in diameter, honey-yellow, with perithecia only on the upper half, and the perithecial part of the clava thicker than the stalk only by the length of the perithecia, which were superficial, crowded, pyriform, 300–400 μ high and about 150–200 μ diameter. In some examples, perithecia were absent from a longitudinal strip down one side of the clava.

In the recent examples, the pupae bear up to a dozen clavae, which are smaller than described by Möller, about 2 cm. high. The stalk is about 0·4 mm. diameter, and merges above into a cylindrical head, about 5 mm. long, at first 0·6 mm. diameter, with an obtuse rounded apex. In the dry state, the stalk is translucent red, externally yellow pruinose, and the head is primrose-yellow, matted fibrillose, with red, slightly projecting ostiola. As the perithecia develop, they become free, superficial, red, with yellow fibrils between them, and the diameter of the head increases to 0·8 mm. The structure of the head is thus similar to that of *Cordyceps militaris*. Perithecia are lacking in a longitudinal streak, which may extend all down one side of the head or only down the lower half of one side. The perithecia are conoid or flask-shaped, 400 μ high, 200 μ diameter, crowded, and the part-spores are rod-shaped, 4–6 × 0·75–1 μ.

This species is now known from Brazil, British Guiana and Costa Rica.

141. *Cordyceps nutans* Pat.

Cordyceps nutans was described by Patouillard from Japan in *Bull. Soc. Mycol. Fr.* III (1887), 127, with fig. 5, pl. 11. It has since become well known through articles published in Japan and specimens distributed from that country, where it occurs on Pentatomids. It was originally described as having the head rufous and the apex of the stalk rufous and decurved, so that the head was nutant, but further specimens show that the head may be erect, and Japanese observers describe the colour of the head and upper part of the stalk as orange, the lower part being black.

I have examined specimens from the Missouri Botanical Garden Herbarium, collected by Clemens in New Guinea in 1937. The collector's note describes the head as red, and in the dried specimens the head is dark red, the upper part of the stalk orange, and the rest of the stalk black. The head is erect. The largest specimen has a stalk 7 cm. long, 1 mm. diameter below, tapering to 0·5 mm. diameter above, with an oval, obtuse head, 5 mm. high, 2·5 mm. diameter. The black rhizomorphic stalk, with fragments of dead leaves adhering

to it, suggested comparison with *C. rhizomorpha* Möller, which was described from a specimen on an indeterminable insect. Möller, however, figured the head of his species as cylindrical, and stated that the perithecia were perpendicular to the surface, whereas in *C. nutans* the head is oval and the perithecia are obliquely vertical, as in *C. sphecocephala*. Incidentally, it may be noted that the host in the type specimen of *C. rhizomorpha* would no doubt be determinable by an entomologist, if it were freed from adhering debris.

142. *Cordyceps stylophora* B. & Br.

Cordyceps stylophora was collected by Ravenel in South Carolina and was described by Berkeley in *J. Linn. Soc.* I (1857), 158. It grew on beetle larvae in rotten wood. It was subsequently described by Cooke in *Vegetable Wasps and Plant Worms* (1892), 109, and by Massee in *Ann. Bot., Lond.*, IX (1895), 16. A few further details have been observed on the type and other specimens.

The clavae are from 1·5 to 3·5 cm. high, and consist of a thin stalk, a cylindrical perithecial portion, and a long sterile tip. The perithecial portion occupies approximately the middle third of the clava, and is abruptly thicker than the stalk and sterile tip. The stalk is 0·3–1 mm. diameter, and the perithecial portion 1–1·75 mm. diameter. When dry, the whole fungus is dark brown, the fertile portion being longitudinally ridged and bearing black, slightly projecting ostiola, but when the clava is soaked the ostiola do not project and do not appear dark. The stalk is brown strigose at the base, but not so strongly as shown by Cooke. The clava has a definite central core, the crowded immersed perithecia being seated on the core and covered by a definite brown cortex, the outer layer of which is composed of longitudinal hyphae, more or less parallel, with short files of rectangular or circular cells. The asci in the type specimen examined were quite immature, only a few having acquired a capitate apex. Massee stated that the ascospores were multiseptate, filiform, 125–135 × 1 μ, with the component cells about 3·5 μ long.

I have examined another specimen, Cornell, no. 14808, on the larva of an Elaterid beetle, coll. H. H. Whetzel, Cayuga Lake Basin, New York, November 1902. In this the perithecia were flask-shaped, 0·36 mm. high, 0·24 mm. diameter, with a pale brown wall. Unfortunately the asci were again immature.

143. *Cordyceps velutipes* Massee

In *Vegetable Wasps and Plant Worms*, Cooke wrote, under the heading, Cape Beetle Club: "Early in the present year (1891), Dr McOwan sent over to this country, from the Cape of Good Hope, three larvae of some coleopterous insect, and, we are assured,

belonging to the family Elateridae, with a *Cordyceps* growing from the front of the head, but unfortunately in an imperfect condition. Two of the specimens had the terminal capitulum broken, and in all of them the perithecia were only just commencing formation. The stems are from one and a half to two inches long, and the clavate head about half an inch. In habit and appearance it approaches *Cordyceps Barnesii*, but without the sterile apiculus at the apex. It is certainly an interesting species, both from its locality and its host, but it would be folly to apply a name without evidence of fructification, although there is not the slightest reason for doubt of its being a true *Cordyceps* and not referable to any described species at present found in this order. The indications of the perithecia are immersed in the substance of the club, at its periphery, and not at all superficial. In one instance there is a second club in process of growth. The lower portion of the stem is slightly velvety."

In his "Revision of the genus *Cordyceps*", *Ann. Bot., Lond.*, IX (1895), 1–44, Massee described this gathering as *C. velutipes*, "solitary, or more frequently gregarious, springing from the under surface of the cervical region of a caterpillar; every part ochraceous brown when dry; stem simple or forked, 2–4 cm. long, 3–4 mm. thick, usually crooked, lower part densely villous, becoming glabrous upwards; head subglobose or broadly ovate, up to 1 cm. long, smooth and even; perithecia completely immersed, elongated, narrowly cylindric-ovate; asci slender, slightly contracted below the capitate apex, eight spored; spores arranged in a parallel fascicle in the ascus, multiseptate, 150–160 × 1 μ, not seen free. 'On larvae of Elateridae.' Type in Herb. Kew.; comm. Prof. McOwan, 'Klerksdorp, S. Afr. Republ., E. G. Alston'."

In the type in Herb. Kew., there are apparently the remains of three coleopterous larvae, which are more or less flat, up to 4 cm. long and 6 mm. broad. The clavae arose from the under surface, just behind the head, and curved upwards. There are four clavae, one very immature and three full grown, but all the latter are damaged and only the lower part of the head now remains in each specimen. Protuberances at the base of the stalk indicate that the clavae may be fasciculate, but the stalks are not forked. The stalks are equal, or expanding upwards, up to 2 cm. high, 2–3 mm. diameter, pruinose or minutely velvety; apparent strigae at the extreme base are hairs of the larvae. Judging from the parts of the head remaining, it would appear to have been clavate, flattened, at least 6 mm. broad, hollow, smooth, ostiola not visible. The lower edge of the perithecial area of the head is irregular, but sharply defined from the stalk. The perithecia are immersed, crowded, subcylindrical or narrowly oval, 0·5 mm. high, 0·12 mm. diameter, with a hyaline wall, ostiola not projecting. There is no definite cortex, the outer layer of the head not

being differentiated from the tissue between the apices of the perithecia, except in colour. The asci are about 250 μ long, cylindrical, capitate, 3 μ diameter, but those seen were too immature to show any spores.

In general structure, *C. velutipes* resembles *C. Melolonthae*.

144. *Cordyceps* on "White Grubs"

An account of *Cordyceps Melolonthae*, which occurs on various species of "White Grub" in America, was published in *Trans. Brit. Mycol. Soc.* XIX (1935), 165–70. In November 1934, I received a specimen of a conidial fungus, found at Apple Hill, Ontario, Canada, on the third year, third instar grub stage of a "White Grub", *Phyllophaga anxia* Lec. It had been found in ground, mostly pasture, which had not been ploughed for six years previously, at a depth of three and a half inches, and was exposed near the bottom of the sod turned up by the plough. "The specimen forwarded was found in a cell, indicating that it had reached the early part of the pre-pupal stage before the fungus became fatal. The tentacle-like arms of the fungus reached into the soil on all sides for a depth of about half an inch."

Strands of mycelium, or clavae, arise from all parts of the insect, and are lax, white, minutely pruinose, about 0·25 mm. diameter, terete or flattened, the branches and the main stems of the clavae apparently extending indefinitely, but generally broken in this specimen and entangled with one another. Conidiophores occur all along the clavae, crowded at the apices, more scattered on the older parts, and are about 20 μ high. Some consist of a simple stem, 8 μ high, 2 μ diameter below, expanding to 3 μ above, and bearing a cluster of about six phialides at the apex, or bearing three oblong prophialides, up to 6 μ long, 2 μ diameter, each with phialides at its apex. Combinations of these two forms occur, e.g. the apex of the main stem may bear phialides directly, together with phialides on prophialides. In other specimens, the main stem is rather closely septate, with branches at the nodes, the branches bearing prophialides and phialides. The phialides are narrowly flask-shaped, or conical, attenuated above, 7–12 × 1·5 μ. The conidia are oval, oblong oval, or oblong with rounded ends, 2–3·5 × 1 μ, with a few subglobose, 1·5 μ, and they remain collected in a globule on the apices of the phialides on each conidiophore.

In the foregoing specimen the fungus is a *Syngliocladium*. It was realized, however, that the clavae might be abnormal, owing to the development of the fungus underground, though on the other hand that might be its normal situation, as in *Isaria dubia*.

In March 1936, I received, from the Central Experimental Farm, Ottawa, specimens of a *Cordyceps* and *Isaria* on *Phyllophaga anxia*,

collected at Clarenceville, Quebec, 28 October 1928. The *Cordyceps* was immature, and had been incubated for four months in the hope of obtaining perithecia. During that time, white clavae, up to 1·2 cm. high, 2 mm. diameter, developed from the larva. These are irregularly conoid or subcylindrical, solid, tapering above, or expanding into a tuft of hyphae, and are encircled at varying heights and for varying distances by a continuous, waxy, orange-yellow zone of conidiophores and conidia. The conidiophores are the same as in the *Synglíocladium* form described above, but they are crowded together in a sporodochium. The fungus in this condition is a stipitate *Tubercularia*. In cultures kindly forwarded from Ottawa, it produces a white, then cream-coloured, loose, cottony mycelium, on which a continuous, waxy, orange-coloured layer of conidiophores and conidia develops. This layer may become ridged, and aculeate with short conical projections, orange-yellow below, white and sterile at the apex. The conidia in culture are chiefly globose, 1·5 μ diameter, with a few oval, 2 × 1·5 μ.

Fig. 3. *Tubercularia* stage of *Cordyceps*, × 2.

The immature *Cordyceps* clavae are described as cylindrical, tapering at the apex, dark slate-purple at the apex (Ridgway, pl. XLIV), somewhat paler at the base, smooth velvety at the base, 1·5 cm. long and 2 mm. diameter at first, becoming 9 cm. long and 4 mm. diameter after four months' incubation. From the dry specimens it would appear that the perithecia, when developed, would be superficial. The colour appears to be wrong for *C. Melolonthae* or *C. acicularis*, and the clava suggests *C. superficialis*. But an identification cannot be made on the available specimens.

Pettit, in *Studies in Artificial Cultures of Entomogenous Fungi*, 1895, *Bull. Cornell Univ. Agric. Exp. Sta.* no. 97, dealt with a conidial fungus on a "white grub", *Lachnosterna*, which he referred with a query to *Cordyceps Melolonthae*. The clavae were 5–9 mm. high, 1–2 mm. diameter, and on their sides they bore shining yellow discs, plane or irregularly concave, composed of conidia held together by some viscid substance. Pettit did not describe the conidiophore nor give the dimensions of the conidia, but it is probable that his species was that described above.

It is evident that there is at least one other *Cordyceps*, parasitic on "white grubs", in addition to *C. Melolonthae*.

145. *Cordyceps armeniaca* B. & C.

This species was considered in *Trans. Brit. Mycol. Soc.* XVIII (1933), 63, where it was recorded that *Cordyceps Langloisii* E. & E. and *C. Ditmari* Quél. were later names for the same species.

I have since had an opportunity of examining another specimen of this species collected by Dr D. H. Linder (no. 600) at Bartica, British Guiana, December 1922. Like the type of *C. Langloisii*, it occurred on the nest of a "mud wasp". The larva within the mud case was covered with white mycelium, and the clavae developed on the exterior of the case. One clava was 2 mm. high, with a flattened globose head, 1·5 mm. diameter, and a stalk, 0·6 mm. diameter in the middle, attenuated at the base and expanding upwards. Another clava had a similar head, 1·2 mm. diameter, and a stalk, 0·5 mm. diameter. Both the stalk and head were minutely fibrillose or pruinose. The collector's note stated that the clavae were light pink on the upper side, but in the dried specimens they were white, purple down one side of the stalk in one example, and partly over the head in the other. The purple colour disappeared in alcohol. After being wetted and dried again, the clava was brown and appeared glabrous, as in the type specimen of *C. armeniaca*. The perithecia were immersed, the upper surface and sides of the head being dotted with translucent, pale amber-coloured ostiola. Perithecia from the lower margin of the head were narrow flask-shaped or narrow conoid, but the specimens were immature.

There are two examples in the type of *C. armeniaca* (Ravenel 3774). One is 9 mm. high, with a head, 1·2 mm. diameter and 0·9 mm. high, and a stalk, 0·3 mm. diameter below, 0·4 mm. diameter above. The other is 8 mm. high, with a head, 1·6 mm. diameter and 1 mm. high, and a stalk, 0·25 mm. diameter below, 0·7 mm. diameter above.

146. *Stereocrea aurantiaca* Petch, n.sp.
Aschersonia aurantiaca Petch, n.sp.

This species was forwarded to me by Mr Erdman West from Gainesville, Florida, where it had been found on *Paraleyrodes perseae* on *Tamala Borbonia*. In appearance it is a *Hypocrella*, but the perithecia, instead of containing cylindrical asci with filiform septate spores which divide into part-spores in the ascus, have fusoid asci with narrow fusoid, septate ascospores which do not divide. The ascospores resemble those of *Ophionectria*, and the genus differs from *Hypocrella* in the same way as *Ophiocordyceps* differs from *Cordyceps*.

Sydow instituted the genus *Stereocrea* for species resembling *Hypocrella*, but having *Ophionectria* ascospores. He defined the genus, however, as having compound stromata, with numerous globose or subglobose lobes, often contracted into a stalk below, seated on a common stroma. The corresponding genus, *Hypocrella*, includes species in which the stroma is simply pulvinate, and others, e.g. *H. Gartneriana* Möller and *H. botryosa* Syd., in which the stroma is deeply lobed, with numerous intermediate forms which make a subdivision

of the genus on that character impracticable. It would seem preferable, therefore, to extend the idea of the genus *Stereocrea* to include species with simple pulvinate stromata and *Ophionectria* ascospores, rather than to institute a new genus for the present species.

The pycnidial stage of *Stereocrea aurantiaca* is a typical Aleyrodid *Aschersonia*, furnished with paraphyses, though the pycnospores are exceptionally large for the genus. Both the perithecia and the pycnidia may occur in the same stroma.

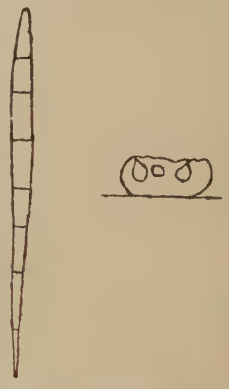

Fig. 4. *Stereocrea aurantiaca*, ascospore, × 500; section of stroma, × 6.

Stereocrea aurantiaca Petch, sp.n. Stromata discoidea, circa 2 mm. diam., 0·75 mm. crass., orbicularia, infra contracta, margine rotundato, supra planiuscula sed minute tuberculata, aurantiaca, ostiolis obscurioribus, pruinosa, interne pallide flava vel albida, hypothallo fibrilloso vel membranaceo cincta; peritheciis late ampullaceis, vel ovoideis supra contractis, ad 0·36 mm. alt., 0·2 mm. diam., pariete crasso; ascis fusoideis, 140–240 × 12–18 μ, apice capitata, poro centrali; ascosporis anguste fusoideis, vel cylindraceis utrinque attenuatis, rectis vel curvis, superne obtusis, basim versus in caudam solidam circa 6 μ long. attenuatis, 110–140 × 4–5 μ, 5–7-septatis, non secedentibus.

Aschersonia aurantiaca Petch, n.sp. Stromatibus ascigeris similia, sed non tuberculata; ostiolis paucis, sparsis vel circulatim dispositis, depressis; pycnidiis lateraliter ovalibus, 0·4 mm. diam., 0·3 mm. alt.; pycnosporis fusoideis, uno fine obtuso, altero producto, 28–33 × 4–5 μ; paraphysibus linearibus, 1 μ diam., ad 250 μ longis.

On *Paraleyrodes perseae* on *Tamala Borbonia*, Gainesville, Fla.

147. *Hypocrella glabrescens* Petch, n.sp.
Aschersonia fimbriata Petch, n.sp.

The specimens which provided the two stages of this species were collected by M. Raymond Mamet, on an Aleyrodid on an indigenous plant on Le Pouce Mountain, Mauritius.

The *Hypocrella* stromata are about 2 mm. diameter, pulvinate or sub-hemispherical, tuberculate with small, sub-hemispherical tubercles, minutely tomentose, becoming glabrous, white, then pale yellow, surrounded by a white fibrillose or scarious hypothallus. The perithecia are flask-shaped, 0·45 mm. high, 0·25 mm. diameter, with a yellow wall, totally immersed, the ostiola yellow at first, becoming inconspicuous. The asci are long cylindrical, capitate, 6–8 μ diameter, and the part-spores cylindrical, then narrow lozenge-shaped, ends truncate, 9–12 × 1·5 μ.

The *Aschersonia* stromata are flattened pulvinate or subcylindrical, about 1·5 mm. diameter, 1 mm. high, with a broad, fibrillose or scarious hypothallus, white, covered with radiating, acute, short fascicles of hyphae, especially at the upper edge, and with a central, orange yellow or yellow mass of pycnospores. Beneath the central mass is a widely open, concave pycnidium, descending to half the depth of the stroma. The pycnospores are narrow fusoid, ends acute, 12–15 × 1·5–2 μ, and are accompanied by linear paraphyses, up to 75 μ long. The stroma has some general resemblance to *A. oxystoma*, but differs in all details. Combinations of the two stages occur, i.e. clusters of *Hypocrella* tubercles may be produced on an *Aschersonia* stroma. This latter form is represented in figure 5.

Fig. 5. Upper, *Aschersonia fimbriata*, section, × 6; lower, *Hypocrella glabrescens*, × 4.

Hypocrella glabrescens Petch, sp.n. Stromatibus pulvinatis vel subhemisphericis, ca. 2 mm. diam., tuberculatis, tuberculis parvis subhemisphericis, minute tomentosis dein glabris, albis dein flavescentibus, hypothallo albo fibrilloso vel membranaceo, ostiolis primum flavis, dein inconspicuis; peritheciis immersis, ampullaceis, 0·45 mm. alt., 0·25 mm. diam., pariete flavo; ascis longe cylindraceis, capitatis, 6–8 μ diam.; articulis sporarum cylindraceis, dein angusto-rhomboideis, truncatis, 9–12 × 1·5 μ. On an Aleyrodid, Mauritius.

Aschersonia fimbriata Petch, sp.n. Stromatibus applanato-pulvinatis vel subcylindraceis, ca. 1·5 mm. diam., 1 mm. alt., hypothallo lato fibrilloso vel membranaceo, albis, fasciculis hypharum acutis brevibus radiantibus, praecipue superiori margine, vestitis, massa sporarum aurantiaca vel flava centrali; pycnidio solitario, profunde concavo, late aperto; pycnosporis angusto-fusoideis, acutis, 12–15 × 1·5–2 μ; paraphysibus linearibus, ad 75 μ longis. On an Aleyrodid, Mauritius.

148. *Aschersonia flavescens* Petch, n.sp.

Specimens of a new species of *Aschersonia*, collected by Mr F. C. Deighton on scale insects on *Raphia* sp. at Nankesi, Gold Coast, 3 September 1937, were submitted to me by the Imperial Mycological Institute. In general appearance the stromata recall *Aschersonia flava*, but they are less regular, often scutate, have larger pycnospores, and lack paraphyses. The present species is a lecaniicolous *Aschersonia*, whereas *A. flava* is aleurodiicolous.

The stromata are pale yellow, circular, scutate or flattened convex, up to 3 mm. diameter and 1 mm. thick in the centre, with a definite, not fimbriate, margin, and without a hypothallus. The surface is "matt", and the ostiola are scattered and inconspicuous, the position

of the pycnidia being sometimes indicated by hyaline or yellowish masses of pycnospores, extruded from the pyriform pycnidia. The pycnospores are broadly fusoid or oval, with ends acute or slightly produced, 14–18 × 4–5 μ. I name this species *A. flavescens*..

With the *Aschersonia* stromata was a single *Hypocrella* stroma, 4 mm. diameter, ashy brown, with dark brown, depressed ostiola. The asci are 200 μ long, capitate, 8 μ diameter when mature, the ascospores dividing in the ascus into cylindrical part-spores with rounded ends, 5–8 × 1·5 μ. The stroma is apparently abnormal, the perithecial stroma having developed on the top of an *Aschersonia* stroma, except in the centre, so that the whole stroma has a double margin and a strongly depressed centre. It would seem advisable to defer the formal description of the *Hypocrella* stage, until further specimens are available.

Aschersonia flavescens Petch, sp.n. Stromatibus flavescentibus, rotundatis, umbonatis vel applanato-convexis, ad 3 mm. diam., medio 1 mm. crass., margine obtuso; ostiolis sparsis, inconspicuis; pycnidiis pyriformibus; pycnosporis late fusoideis vel ovalibus, acutis vel leniter productis, hyalinis, 14–18 × 4–5 μ; paraphysibus nullis. On a coccid on leaves of *Raphia* sp., Gold Coast, West Africa.

149. *Aschersonia simplex* Petch, n.sp.

This species, kindly furnished me by M. Raymond Mamet, was found on leaves of an undetermined tree on Le Pouce Mountain, Mauritius. The stromata are subcylindric or subconoid in the centre, rounded above, and expanded gradually below into a discoid base with a stout, entire margin. They are pruinose, brownish yellow, red round the ostiolum, about 1·25 mm. diameter, with the central cylindrical part about 0·8 mm. diameter, and a total height of 0·6 mm. Each stroma contains a single pycnidium, which is central, globose, 0·5 mm. diameter, convoluted below, while the ostiolum is depressed and occupies the greater part of the apex. The pycnospores are oval, ends acute but not produced, 10–12 × 3·5–4·5 μ, on short, stout basidia, without paraphyses. The host insect was not observed, but from its structure, this species is lecaniicolous. It bears a general resemblance to *Aschersonia duplex* Berk. and *A. cubensis* B. & C., but differs from the former in the absence of paraphyses, and from both in the shape of the stroma and the pycnospores.

Fig. 6. *Aschersonia simplex*, section, × 10.

Aschersonia simplex Petch, sp.n. Stromatibus medio subcylindraceis vel subconoideis, 0·8 mm. diam., supra rotundatis, basi expansis, 1·25 mm. diam., 0·6 mm. alt.; margine crasso, integro; pruinosis, brunneo-flavis, supra rubris; ostiolo apicali, solitario, depresso;

pycnidio solitario, globoso, 0·5 mm. diam., infra convoluto; pycnosporis ovalibus, acutis sed non productis, 10–12 × 3·5–4·5 μ; paraphysibus nullis. Mauritius.

150. *Isaria atypicola* Yasuda

This species was recorded by Lloyd in Letter 54, p. 6, note 223, January 1915, as an unnamed *Isaria* from A. Yasuda, Japan, which had been sent as *I. arachnophila* Ditm. Lloyd pointed out that as it had club-shaped clavae 6 cm. or more long it could not be that species, but was something new. In a later number of the same series, Letter 56, p. 9, note 257, n.d., Lloyd gave further details of the fungus from Professor Yasuda, who stated that he proposed to describe it as *I. atypicola*. It was said to grow on the spider, *Atypus Karschi* Doenitz, "which makes a long tube underground", the club-shaped clava projecting a centimetre or more from the mouth of the tube. The upper part of the clava was said to be light purple, with a velvety appearance and bearing cylindrical conidia. Actually, the fungus is on a trapdoor spider, which makes a short nest, not a long tube. The spider, covered with white mycelium, lies at the base of the nest, and the cylindrical clava pushes aside the lid and emerges above ground.

Yasuda described the fungus as *Isaria atypicola* in *Bot. Mag. Tokyo*, xxxi (1917), 208, 9, with a figure and a reference to *Crypt. Japon. Icon. Illustr.* i, no. 5, pl. 25. In the same journal, xliv (1930), 40–42, Yakushiji and Kumazawa stated that *I. pachylomera* Kawamara was the same species, and that the determinations of the host as a species of *Atypicola* and *Pachylomera* were incorrect, the spider being *Kishinoyeus typicus* Kisida.

Hitherto the fungus has been known only from Japan. Through the kindness of Professor C. W. Dodge, I have been able to examine two collections in the Missouri Botanical Garden Herbarium, collected by Dodge and Georger in Costa Rica in 1936 (nos. 9009 and 9013). The specimens are smaller than those reported from Japan, the largest clava being 3 cm. high, with a short stalk, 1·5 mm. diameter, and a cylindrical head, 3 mm. diameter, almost equal, obtuse and rounded at the apex. In the dried specimens, the head is ashy or purple-grey, covered by a dense "pile" of conidiophores and conidia. The conidiophores are spicarioid, with a main stem, 3–4 μ diameter, which bears dense clusters of prophialides and phialides at the nodes and at the apex, presenting an appearance similar to that of *Spicaria prasina*. The prophialides are cuboid, 5–6 × 4 μ, and the phialides clavate or cylindrical, obtuse, 4–5 × 2 μ. The conidia are cylindrical or narrowly oval, ends obtuse, hyaline, catenulate, 4–6 × 1·5–2 μ. The clava appears black internally, but when soaked the tissue is dark red and subgelatinous.

If classified according to the type of conidiophore, this species must be known as *Spicaria* (*Isaria*) *atypicola*. The colour, consistency and shape of the clava are the same as those of *Cordyceps cylindrica* Petch, and there seems little doubt that it is the conidial stage of the latter.

151. *Tilachlidiopsis nigra* Yakus. & Kumaz.

When examining entomogenous fungi from the collection in the Berlin Herbarium, I found conidial clavae in the specimens of *Cordyceps entomorrhiza* collected near Leipzig in 1866 and 1867 by Auerswald and Delitsch, and issued in Rabenhorst, *Fungi Europaei*, nos. 1010 and 1218 and Rehm, *Ascomyceten*, no. 1288. These were described in *Trans. Brit. Mycol. Soc.* XVIII (1933), 55. The clavae were black, with a white, subglobose, ovoid, or laterally flattened apex, with the structure of a *Stilbella*, and as similar conidial clavae occurred as lateral branches of the perithecial clavae, it was assumed that these were the conidial stage of *Cordyceps entomorrhiza*. It appeared that this was *Clavaria setiformis* Vahl, and it was re-described as *Stilbella setiformis* (Vahl) Petch.

Subsequently a series of specimens of *S. Kervillei* from the Creswell Caves, Derbyshire, was submitted to me, and from these it was possible to determine that this fungus was not parasitic on flies, as had been supposed, but on a *Hirsutella* which was parasitic on flies. Later, on examining a collection of fungi from the Farlow Herbarium, it was found that *Stilbella ramosa* (Peck) was parasitic on *Hirsutella gigantea* Petch and on what is apparently its perithecial stage, *Cordyceps elongata* Petch. These facts were published in *Trans. Brit. Mycol. Soc.* XXI (1937), 52, where it was stated that *Stilbella ramosa*, *S. Kervillei* and *S. Arndtii* were the same species. I am now of opinion that *S. setiformis* is the same fungus; it is *S. ramosa*, parasitic on the clava of *Cordyceps entomorrhiza*. As *Clavaria setiformis* is pre-Friesian, and the name was not taken up by Fries, it would appear that Peck's name must be used.

In the first of the communications cited above, reference was made to *Isaria nigra* Yakushiji and Kumazawa, described in *Bot. Mag. Tokyo*, XLIV (1930), 40, from specimens found on *Carabus Gehini* in Japan, and its resemblance to *Stilbella setiformis* was pointed out. In the same journal, XLIV (1930), 461, these authors transferred their species to *Tilachlidiopsis*, and in vol. LI (1937), 97–102, Y. Kobayasi gave a full account of it under the title, "On the specific connexion of *Cordyceps entomorrhiza* and *Tilachlidiopsis nigra*". He gave figures showing the conidial clava with a terminal conidial head, and bearing short lateral branches, perpendicular to the main stem, with similar conidial heads, and also perithecial clavae, with similar branches on the stalk and on the perithecial head. It seems clear from these

figures that *Tilachlidiopsis nigra* is similar to *Stilbella setiformis*, and is a *Cordyceps* clava parasitized by a *Stilbella*.

Stilbella ramosa is parasitic on species of *Hirsutella*, or on species of *Cordyceps* which have a *Hirsutella* conidial stage, so far as is known at present. It may occur on the mycelium, and is then a simple *Stilbella*. In the larger, branched specimens, the main stem is usually that of the host, the lateral branches being the simple *Stilbella*. This would no doubt have been quite evident, were it not that the *Stilbella* is produced also at the apex of the host clava, in line with it and without any abrupt change of diameter. Hence all observers have been misled into supposing that the whole branched structure is one fungus.

From the data available, it would appear that the *Stilbella* in *Tilachlidiopsis nigra* is not *Stilbella ramosa*. The conidia of the latter, as given by various authors, are small, oval, $1{\cdot}5–3{\cdot}5 \times 0{\cdot}75–2\,\mu$, or globose, $1–2\,\mu$. The accounts of the former are extraordinarily conflicting. It was originally described as having conidia, $3{\cdot}5–5 \times 0{\cdot}8–0{\cdot}9\,\mu$, but that was corrected to $7–10 \times 2\,\mu$. Kobayasi, however, stated that it had two kinds of conidia, the one cylindric, obtuse above, pointed below, $10–12 \times 1{\cdot}7–2\,\mu$, and the other shorter, $4{\cdot}2–7 \times 2{\cdot}1–2{\cdot}8\,\mu$. It would appear therefore that this *Stilbella* is a different species, but it would be interesting to know whether some of these measurements refer to *Hirsutella* conidia.

The occurrence of *Stilbella ramosa* on the clava of *Cordyceps entomorrhiza* makes it probable that the conidial stage of the latter is *Hirsutella eleutheratorum* (Nees) Petch. That can be decided only by growing the *Hirsutella* from the ascospores of the *Cordyceps*. Unfortunately, the latter has not been correctly reported for Great Britain since its original record by Dickson in 1785, and Japanese specimens so far reported have been imperfectly developed and did not contain ascospores.

The genus *Tilachlidiopsis* was founded by Keissler in *Ann. Naturh. Mus. Wien*, XXXVII (1924), 215. One of the species is *T. hippotrichoides* (Lind.) Keissl., originally stated to grow on the ground, but since found to be entomogenous and recorded on the hemipteron, *Nabis ferus* L. It is possible that this is another instance of a *Stilbella* parasitic on an entomogenous fungus, but its conidia are said to be $7{\cdot}7–9{\cdot}6 \times 1{\cdot}5–2\,\mu$.

152. *Isaria exoleta* Fries

Reference was made to this species in *Trans. Brit. Mycol. Soc.* XVIII (1933), 70, where it was recorded that there was no type specimen in the Fries Herbarium. In 1936, I obtained three specimens which answer to Fries's description, and these were described in *The Naturalist*, November 1936, pp. 250, 251. The details are re-published in this series for convenience of reference.

The first British specimen was found by Mr W. G. Bramley on a lepidopterous pupa in moss on a poplar log at Steeton Whin, near Tadcaster, Yorks, July 1936. Two others were collected on lepidopterous pupae under moss on a cliff face at Hubberholme, Yorks, September 1936. In the latter instance, the pupae were at the base of the moss, and the fungus was not observed until the moss was stripped off the rock.

The pupa bears up to eight clavae, arising close together or scattered, up to 5 cm. long, 0·25 mm. diameter, tapering upwards, linear, simple or branched, terete when fresh, becoming twisted and longitudinally furrowed when dry, brownish black below, but ashy above owing to the presence of conidia. The clavae resembled an immature *Xylaria*, but on examination they proved to be a *Hirsutella*. The phialides are 20–40 μ high, and consist of an inflated base, usually flask-shaped but often irregular, 12–18 × 5 μ, attenuated above into a stout sterigma, 20 μ long. Sometimes the phialides do not form a continuous layer, but occur in more or less scattered clusters. The spore cluster is oval or lemon-shaped, 10 × 7 μ, and the individual conidia are hyaline, cymbiform, ends rounded, 9 × 2·5 μ. By transmitted light, the outer layer of the central core is fuliginous.

This is evidently *Cordyceps fuliginosa* Ces., described by Cesati from a specimen on a pupa of *Bombyx antiqua* in Italy. Cesati described his species as having cylindrical clavae, 14–17 mm. long, 1 mm. diameter, attenuated upwards, ashy, almost with the habit of *Xylaria scopiformis*. His figure of the whole fungus on the pupa shows short linear clavae, while an enlarged figure of part of a clava under pressure shows a central core of parallel hyphae, with a confused outer layer of conidia, etc. It is evident that Cesati's fungus was not a *Cordyceps*, but a conidial form, though the details are indecipherable.

The synonymy of this species is:

Hirsutella exoleta (Fr.) Petch, in *Naturalist*, November 1936, p. 251; *Isaria exoleta* Fr., *Syst. Mycol.* III (1832), 275; *Cordyceps fuliginosa* Ces., *Comment. Soc. Critt. Ital.* I (1861), 67.

153. *Hirsutella verticilloides* V. K. Charles

This species was described by Miss V. K. Charles from specimens on "Lace Bugs" (*Leptopharsa Heveae*) on *Hevea brasiliensis* from Para in *Mycologia*, XXIX (1937), 216–221.

Typical species of *Hirsutella* have a clava which bears a palisade layer of phialides, but some species have merely phialides on repent mycelium, the latter being classed as *Hirsutella* because of the shape of their phialides and the apical head of conidia bound together by mucus. In the present species clavae are lacking, and it has simple, erect conidiophores up to 450 μ high, with verticillate phialides.

Moreover, the conidia are described as solitary, not in heads. It would not, therefore, be a *Hirsutella*, and in fact it appears to be the same as *Verticillium fuliginosum* Petch, described in *Trans. Brit. Mycol. Soc.* XIX (1935), 186, from specimens on leaf-hoppers on sugar cane, collected in Surinam and Panama.

154. *Hirsutella strigosa* Petch, n.sp.

This species was found on a leaf-hopper on Bamboo at Nuwara Eliya, Ceylon, in December 1926 and December 1927. It occurred with the *Hirsutella* which is common on leaf-hoppers in Ceylon, *H. versicolor*, but differs from that species in its mycelium and conidia.

The mycelium is tawny brown, coarse, loose and strigose, covering the insect and spreading widely over the adjacent leaves for a distance of 1 cm. or more in a byssoid sheet or in strands. The hyphae are stout, regular, 4–5 μ diameter, without any swellings or pseudo-conidia. The phialides are scattered, lateral or terminal on the hyphae, up to 36 μ high, 2 μ diameter at the base, elongated conoid, attenuated into a rather stout sterigma, or up to 50 μ high, with a subcylindrical base, up to 20 μ high, attenuated into a sterigma 30 μ long. Sometimes the fungus forms small erect tufts, 0·6 mm. high, 0·2 mm. diameter, composed of loosely interwoven hyphae, bristling with phialides, on the insect, but no definite clavae. The spore cluster is oval, 12 × 5 μ, or lemon-shaped, 16 × 8 μ, or globose, 12 μ diameter, and the conidia are cymbiform or narrowly oval, sometimes attenuated at one end, 8–12 × 3–5 μ.

Hirsutella strigosa Petch, sp.n. Mycelio rufo-brunneo, laxo, strigoso, insectum et folia obducente; hyphis regularibus, crassis, 4–5 μ diam.; phialidibus sparsis, lateralibus vel terminalibus, longe conoideis, ad 36 μ alt., basi 2 μ diam., supra attenuatis, vel basi subcylindraceo, 20 μ alt., in sterigmate 30 μ alt. attenuato; globulis sporarum ovalibus vel limoniformibus vel globosis; conidiis cymbiformibus vel angusto-ovalibus, interdum uno fine attenuatis, 8–12 × 3–5 μ. On a leaf-hopper (Hemiptera), Nuwara Eliya, Ceylon.

155. *Oospora ovorum* Trabut

Oospora ovorum was described and figured by Trabut in *Rev. gén. Bot.* III (1891), 404, pl. 17, fig. 5. It occurred on the eggs of *Acridium peregrinum* in Algeria, and was said to be white, with globose conidia, 0·7 μ diameter, in spiral chains of twenty to thirty. Maire, in *Bull. Soc. Hist. Nat. Afrique Nord*, VIII (1917), 184, recorded that he had found it in abundance on the eggs of the same host, and gave cultural details, stating that it formed a felt of hyphae, 0·7–0·8 μ diameter, which gave rise to a fine tomentum of more slender hyphae, 0·4–0·5 μ diameter, often spirally twisted, terminated by spiral chains of

slightly elongated conidia, 0·6–0·8 × 0·5 μ. Maire suggested that the fungus should be classed with *Oospora pulmonalis*, *O. buccalis*, etc.

I have received a specimen of the same, or a closely allied, fungus, on a Curculionid found in timber at Reduit, Mauritius, by M. Raymond Mamet. It forms a small white powdery patch externally at the junction of the abdomen and the thorax. The hyphae are regular, 0·8 μ diameter, with branches 0·5 μ diameter, bearing terminal chains, sometimes branched, of globose conidia, 0·5 μ diameter. Spiral hyphae were not observed. On morphological characters, it would appear that this should be included, at least provisionally, under *O. ovorum*, pending further knowledge of the occurrence of fungi of this type on insects.

156. *Cephalosporium nodulosum* Petch, n.sp.

This fungus, now in the Missouri Botanical Garden Herbarium, was collected by Clemens in New Guinea in December 1937, on a moth (Pyralid) attached with outspread wings to a leaf. It covered the body of the insect with a thin white felt, and spread out along the wings and over the leaf. The hyphae are stout, up to 4 μ diameter, diminishing to 2 μ and inflated at intervals into angularly globose swellings, 3 μ diameter. These swellings may give rise to conidiophores, as many as six from one swelling, or to hyphae, or to a mixture of both. Conidiophores may also arise from a similar swelling at the apex of a short, stout, lateral branch, about 15 μ long. The conidiophores are simple, subulate, 10–20 μ high, 1·5 μ diameter at the base, with heads of conidia about 10 μ diameter, and the conidia are hyaline, oval, 2–3 × 1 μ.

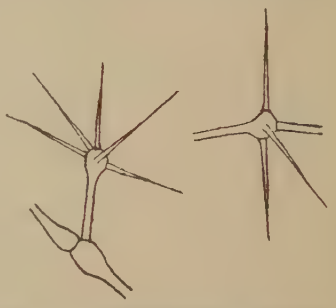

Fig. 7. *Cephalosporium nodulosum*, conidiophores, × 1000.

Cephalosporium nodulosum Petch, sp.n. Mycelio albo, effuso, tenui, subcompacto; hyphis crassis, 4 μ diam., ad 2 μ attenuatis, hic illic ad 3 μ subgloboso-inflatis; conidiophoris ex inflationibus oriundis, simplicibus, subulatis, 10–20 μ alt., basi 1·5 μ diam.; conidiis hyalinis, ovalibus, 2–3 × 1 μ, in globulis 10 μ diam. On a moth (Pyralidae), New Guinea.

157. *Ypsilonia cuspidata* Lév.

This species was described by Léveille in 1846 from specimens from the Philippines on the lower surface of the leaves of an anonaceous plant. He stated that it had minute perithecia (pycnidia) on a black radiating hypothallus, 3–4 mm. wide, with three-radiate, Y-shaped, continuous spores, whence the name. In 1914, Sydow

described it again from the Philippines on an anonaceous plant as *Psalidosperma mirabilis*, the generic name being based on the supposed resemblance of the four-armed spores to an earwig. Von Höhnel examined Léveillé's type, and found that it was the same as Sydow's species, the spores really having four arms, but with two of the arms often in contact. Von Höhnel stated that it was quite improbable that the peculiar spores were produced in pycnidia, and Sydow was doubtful about the existence of such a structure. Sydow noted that the fungus was readily separable from the host plant.

I have received examples of this fungus from M. Raymond Mamet, Mauritius, on a scale insect, *Fiorinia elaeodendri* de Charm. *Pseudomicrocera Henningsii* (Koord.) Petch also occurs on the insects on the same leaves, and there is a possibility that *Ypsilonia cuspidata* is parasitic on the *Pseudomicrocera* and not on the insect itself. It forms a thin black circular stroma, about 2 mm. diameter, with an entire or fimbriate margin, and bearing here and there groups of black setae and black conoid tubercles which look like pycnidia. The setae are black or blackish brown, up to 300 μ high, 3 μ diameter, rigid, regular, and among them are discoid acervuli, consisting of short, stout, simple conidiophores, fuscous below, hyaline above, arising from a black, parenchymatous tissue, or sometimes from a short, stem-like base. The setae sometimes arise beneath the acervulus and curve upwards, being fasciculate at the base and divergent above. The apparent tubercles are composed of similar setae which converge over the acervulus. There does not appear to be any pycnidial wall, and the fungus should be placed in the Tuberculariaceae.

The spores consist of two narrowly cylindrical, septate members, 3 μ diameter, usually straight below and curved above, united to one another about the middle by a short projection from one of them, thus forming a four-armed spore. The two upper arms are widely divergent and approximately equal in length, while the two lower are usually straight and almost in contact, though sometimes curving inwards and crossing. These two lower arms may be of the same length and obtuse, or one may be double the length of the other and terminate in an acute tip. The lower arms are three to four septate, but the upper may be continuous, or not more than one or two septate. The colour of the spore when mature is pale fuscous. The total over-all length, measuring from the base to an imaginary line across the ends of the upper arms, is 75–95 μ. When the margin of the stroma is fimbriate, it consists of bundles of setae, similar to those already described, lying flat on the leaf.

158. *Haplographium coccorum* Petch, n.sp.

This species, which occurred on *Galeraspis eugeniae* Mamet on an indigenous tree, was sent to me from Mauritius by M. Raymond

Mamet. It forms a greyish brown, compact, thin stroma, spreading indefinitely over the leaf, cloudy and film-like at the margin, but becoming about 50 μ thick, and splitting and recurving from the leaf on drying. The stroma consists of thick-walled hyphae, hyaline at the base of the stroma, brown or yellow-brown above, septate, 3–4 μ diameter, sometimes running parallel in strands and giving off lateral branches which are variously curved and intertwined. The conidiophores are scattered over the stroma and appear as black bristles, up to 150 μ high, 6–7 μ diameter below, tapering to 3 μ above and expanding again to 4 μ at the apex, rigid, brown or blackish brown, simple, septate, terminating in a persistent, pale fuscous, ovoid head, about 12 × 9 μ, which consists of oval phialides, 4 × 2 μ, bearing pale fuscous, oval conidia, 2–4 × 1 μ.

Haplographium coccorum Petch, sp.n. Stromatibus effusis, fuliginosis, tenuibus, compactis, ex hyphis 3–4 μ diam. compositis; conidiophoris ad 150 μ alt., infra 6–7 μ diam., supra attenuatis, 3 μ diam., apice incrassatis, 4 μ diam., brunneis vel nigro-brunneis rigidis, septatis, simplicibus; capitibus persistentibus, ovalibus, circa 12 × 9 μ; phialidibus ovalibus, 4 × 2 μ; conidiis pallide fuscis, ovalibus, 2–4 × 1 μ. On *Galeraspis eugeniae* (Coccidae), Mauritius.

159. *Stemphyliopsis ovorum* Petch, n.sp.

Some apology is needed for the inclusion of this species, which is not an entomogenous fungus, in the present series, but its description has been awaiting publication for more than ten years, and it would seem less out of place here than in a general list of fungi. It occurred on the eggs of *Achatina fulica*, known in Ceylon as the Kalutara snail,

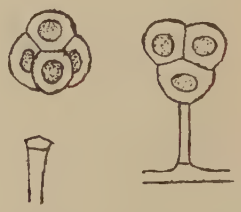

Fig. 8. *Stemphyliopsis ovorum*, conidium; ditto, attached to mycelium; apex of conidiophore in optical section, × 1000.

and interfered with breeding experiments during investigations into the life history of that pest which were being conducted by the Entomological Division of the Department of Agriculture, Ceylon, in 1927.

The mycelium forms a thin, powdery film, white becoming yellowish, over the eggs. The hyphae are hyaline, regular, septate, 1·5 μ diameter, and bear short lateral conidiophores up to 10 μ long, 1 μ

diameter, slightly expanded at the apex, each bearing a single compound conidium. The conidium consists of from three to six cells, not all in the same plane, forming an irregularly globose or ovoid spore, from 9 μ diameter to 16 × 12 μ. The individual cells, as seen in optical section, are wedge-shaped, 7–9 μ broad, with a strongly convex outer surface, and very thick-walled, with a wall 2–3 μ thick. The whole spore is hyaline and smooth. The conidiophore has a septum about 2 μ below the spore, and normally the detached conidium has a short pedicel of that length. In the figure, the lumen of each cell is stippled for clearness.

Stemphyliopsis ovorum Petch, sp.n. Mycelio tenui, albo, farinoso; hyphis regularibus, septatis, hyalinis, 1·5 μ diam.; conidiophoris lateralibus, simplicibus, unisporis, ad 10 μ alt., 1 μ diam., apice leniter incrassatis, juxta apicem septatis; conidiis terminalibus, 3–6-cellulosis, globosis, 9 μ diam., vel ovoideis, ad 16 × 12 μ, hyalinis, levibus, cellulis cuneatis, exteriore convexis, parietibus 2–3 μ crassis. On the eggs of *Achatina fulica* (Gasteropoda), Peradeniya, Ceylon.

160. *Rotaea flava* Ces.

Cesati contributed to Rabenhorst, *Klotzschii Herbarium vivum Mycologicum*, etc., Cent. xv, no. 58, specimens for which he instituted the genus *Rotaea*, with the species *Rotaea flava*. The description was published in *Bot. Ztg.* IX (1851), 180, and stated that the genus belonged to the tribe Alphitomorpheae and constituted a transition to the Sphaeronemeae. In Wallroth, *Flora Germanica*, the genus *Alphitomorpha* is chiefly *Erysiphe*, while *Sphaeronema* is the next genus. *Rotaea* was defined as having sessile, membranous peridia, with simple, free, subglobose or somewhat polygonal spores, emerging from the apex in a globule. The type species, *Rotaea flava*, grew inside the empty cocoons of the Goat Moth, rarely on the exterior. The peridium was covered with septate hyphae, more densely towards the base, from which the hyphae sometimes, though rarely, spread out in a thin yellow layer over the substratum. The effete peridia formed flattened white cups, almost resembling the conceptacles of *Myrothecium*.

Bonorden, in *Bot. Ztg*, XI (1853), 283, stated that he had examined a specimen, Rabenhorst, no. 1458, and had found on it a fungus which he described and figured. It formed rounded or ovoid yellow masses, about 0·5 mm. diameter, which appeared rough under a lens, tuberculate on the upper half. His figure shows an ovoid, warted mass, attenuated below into a short stalk. When this was placed in water, the outer zone was resolved into minute granules and the spores were set free. The spores were in small clusters, arising from a "root-like" basal mycelium, which extended over the sub-

stratum and was in part glued together in the outer zone of the mass. His figure shows clavate, multiseptate conidia, arising separately from repent hyphae. Bonorden concluded that the fungus was a *Sporodesmium*, which secreted a yellow slime by which the spores were bound together. He was unable to find any other fungus on the specimen, but left the question of the identity of the *Sporodesmium* with *Rotaea flava* undecided, pending the examination of other examples of Rabh., no. 1458.

Subsequent writers have attached Bonorden's description to Cesati's name, Saccardo suggesting that Cesati had examined an immature specimen. That, however, would hardly seem probable, in view of his description of the spores as globose and issuing in a globule. It would appear more likely that the authors in question were dealing with different fungi. Bonorden described the spores as yellow, and hence the fungus would now be included in *Sporodesmium*. He did not give the dimensions of the spores, but from his figure they were evidently large, and his account suggests that the fungus he examined was *Bactridium flavum*.

As the fungus occurred on the empty cocoon of the Goat Moth, there is no reason to regard it as an entomogenous fungus. It is probably merely a lignicolous species.

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TRICHODERMA VIRIDE PERS. EX FRIES, AND NOTES ON *HYPOCREA*

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(With 5 Text-figures)

Introduction and historical summary

With the increased interest in *Trichoderma* in recent years, and the description of several new species, the difficulty in specific identification has increased. My views are here presented on the taxonomy of the forms commonly encountered. I am very grateful to E. W. Mason of this Institute for providing cultures, specimens, and sound advice, to Miss E. I. McLennan of the University of Melbourne for sending her notes on *Trichoderma* and *Hypocrea* (from which quotations are given below), and to M. I. Timonin of Ottawa for many cultures and for assistance since 1932 in the study of *Trichoderma*.

Persoon in 1794 founded the genus *Trichoderma*. *T. viride* was described briefly as the first species, with *Pyrenium lignorum* var. *vulgare* Tode, 1790, listed as a synonym. Some confusion in the nomenclature of this species arose during the next few years, but Fries (1829, p. 215, with citations of literature) reduced to synonymy the names he considered to belong to *Trichoderma viride* Pers. ex Fr. This is the type species of the genus. For more than seventy years after Fries, only the one green species was definitely recognized.

It is true that from time to time before Fries and up to 1900 other fungi were described briefly as species of *Trichoderma*, but none of these has yet been verified as a *Trichoderma* distinct from *T. viride*. As Saccardo remarked in compiling thirteen names in *Trichoderma* in the *Sylloge* (1886), all but *T. viride* were doubtful because the method of spore formation was unknown for the twelve others. Only *T. album* Preuss (which Lindau (1904) considered certainly not to belong to the genus) need be mentioned here, for the name has been used for certain cultures from soil, as mentioned below.

Fries and other early mycologists interpreted *Trichoderma* as a Gasteromycete, but Tulasne in 1860 found that it was one of the Fungi imperfecti. The brothers Tulasne (1865) made the brilliant observation that *T. viride* was connected with *Hypocrea rufa*, and illustrated beautifully the conidiophores with phialides surmounted by small

heads of conidia, and did not overlook the chlamydospores. The conidia were described as spherical or broadly ovate, smooth, "hardly exceeding 3·5 μ in the greater diameter, and growing solitary, or shortly moniliform-concatenate, or even fasciculate".

Harz (1871) presented an emended description of the genus *Trichoderma*, with all the emphasis on microscopic characters, and

Fig. 1. From Vuillemin (1887), showing (no. 88) the attack of *Trichoderma* on a hypha of *Mucor*.

included only the one species. His figures are good, but Tulasne's show better the usual form of phialide and conidiophore. Harz revived Tode's name, and made the new combination *T. lignorum* (Tode) Harz. Although this name was accepted by Saccardo and many subsequent workers, it is invalid under the present International Rules.

Vuillemin (1887) used the name *Acrostalagmus viridis*, noted the odour of cultures as "pénétrante, légèrement camphrée", and presented good figures, including the attack of *Trichoderma viride* on

a hypha of *Mucor* (Fig. 1). He reported pycnidia, but these must have belonged to another fungus: his figures suggest *Phoma glomerata* (Corda) Wollenw. & Hochapfel (*Coniothecium scabrum* McAlpine).

Brefeld (1891) proved by pure cultures that the ascospores of *Hypocrea rufa* developed *Trichoderma viride* as the conidial stage, thus verifying Tulasne's observations. Brefeld also reported on the conidial stage of *Hypocrea gelatinosa* (see below).

Oudemans in 1902 described *Trichoderma Koningi* from soil. This name also has been transferred to *Acrostalagmus* (Duché & Heim, 1931). Since 1902, *Trichoderma Koningi* has appeared in the literature about equally with *T. viride*. Lindau (1904) listed as doubtful all names except *T. viride* and *T. Koningi*. Bainier (1906) gave notes and figures of his interpretation of the two species. He also transferred *Pachybasium hamatum* (Bonord.) Sacc. to *Trichoderma*, and described as new *T. minutum*, another *Pachybasium*. Bainier has not been followed as regards *Pachybasium*.

Cook & Taubenhaus (1911) compared *Trichoderma Koningi* with *T. lignorum* (both determinations by Thaxter), and reported certain apparent differences. C. N. Jensen (1912) described briefly the appearance of cultures attributed to the two species. Miss Dale (1912, 1914) reported from soil *T. Koningi*, *T. lignorum* with echinulate spores, and revived the name *T. album* for a white form which, to judge from her figures, was not a *Trichoderma*.

Goddard (1913) described as new *T. nigrovirens*, which he said was a common fungus in soil. Gilman & Abbott (1927) considered that it may have been *T. viride*, but Goddard's description and figures leave one in doubt.

Waksman (1916) reported from soil *Trichoderma* strains I–V, with brief descriptions of cultural characters and morphology: I was interpreted as *T. Koningi*, II as *T. lignorum*; III, IV, and V were not named. Waksman also included "*T. album* Preuss" with spores 2·5–2·9 × 1·8–2·1 μ, in heads on lateral conidiophores.

Abbott (1926) studied seven isolations of *Trichoderma* from soil, which "constitute a series of intergrading forms, which show sufficient cultural differences to be considered as separate species when observed individually", but he decided they could be placed as four species: *T. lignorum*, *T. Koningi*, and *T. glaucum* n.sp., for which cultural and morphological characters are given, and the fourth species not named. Abbott's conclusions were no doubt reasonable at the time, when there was less information available regarding soil fungi, and the appearance of fungi in culture: but one cannot help wondering how he would have placed seven hundred isolations of *Trichoderma*.

Other names and literature are included below.

Notes on certain specimens and cultures

Persoon's herbarium contains six specimens marked *Trichoderma viride*. These represent his concept of the species, and one of them must be the lectotype of the genus and species. Thanks to the Director of the Rijksherbarium at Leiden, I was given the privilege of examining these specimens. Six slides showing microscopic characters are filed at the Imperial Mycological Institute.

Rijksherb. no. 148–1 is marked in Persoon's handwriting "*Trichoderma viride* P. (Prope Pariosos)". It consists of a piece of rough bark 5 × 3 cm. bearing about a score of tufts of the *Trichoderma* in the mature condition, i.e. each tuft (0·5–1·5 mm. in diam.) is dark olive-green, and under a binocular microscope is seen to consist of a mass of dark spores and a few projecting hyphae. A permanent mount was made, which shows the spores to be now pale greenish brown, globoid, 2·5–4 μ, or ovoid, 3·5–5 × 2·5–3·5 μ, surface (as seen with oil immersion) slightly roughened; many clusters of spores still present, and a few typical phialides were seen.

Rijksherb. 148–2 is marked, in Persoon's handwriting, only "*Trichoderma viride*". It consists of a piece of bark 55 × 30 mm., evidently from a kind of tree different from that of 148–1. It bears a few tufts of spores so dark that they hardly look like *T. viride* under a lens; but under a binocular the tufts appear more typical. A mount of spores showed them to be mostly oval, 3–4 × 2·5–3 μ, sometimes globoid, 3–3·5 μ, slightly roughened, often in clusters or "heads".

Rijksherb. 148–3 is marked "*Trichoderma viride*", not in Persoon's handwriting, and in another hand "Hb. Nees v. Esenb." It consists of a bit of smooth bark 25 × 10 mm., with three or four typical tufts of *Trichoderma*. The spores are mostly globose, 2·5–3·5 μ, slightly rough.

Rijksherb. 148–4 is marked by Persoon "*Trichoderma viride* var. *aeruginosum*. Saltem formam magis regularem habet et magis compactum et tomentosum est." It consists of two pieces of bark from a branch or sapling, one mossy, 8 × 1–2 cm., one smooth, 6 × 1·5 cm. The former bears several large tufts 2–5 mm. in diam., or larger by confluence, rather young with a white margin. The smaller piece bears smaller and more mature tufts. Spores from the mossy bark are oval to subglobose, 3–4 × 3–3·5 μ, nearly smooth.

Rijksherb. 148–5 is marked by Persoon "*Trichoderma viride* var. *aeruginosa*". It consists of four pieces of bark bearing numerous tufts of what is apparently young *Trichoderma* still white, but with a suggestion of green colour at the centre of many tufts. A slide was made, and some globoid to ovoid spores, and a few typical phialides of *Trichoderma* were found.

Rijksherb. 148–6 is marked in an unknown hand "*Trichoderma viride* var. *verruginosa*. Herb. Pers. Doublette." What is obviously meant is "var. *aeruginosa*". The specimen consists of several bits of bark with *Trichoderma*, apparently like no. 148–4. The fungus was not studied microscopically.

No. 1 or no. 2 must be chosen as the type specimen, and it seems best to designate no. 1 as lectotype. The examination of Persoon's specimens made it clear that the present-day concept of *Trichoderma viride* is correct, i.e. the same as that of Persoon. Considerable variation in spore characters is evident in his specimens.

Since the time of Persoon thousands of specimens have been filed away in herbaria. Kew Herb. has about sixty specimens in the *T. viride* folder, which extend the idea of the species from Persoon to the

present time. A "random sample" of these specimens was examined for important spore characters:

(1) Collected about 1800, marked "*Trichoderma aeruginosum* Pers. in litt., *Mucor lignifragus* Bull." Spores subglobose, 3–4 (5) μ, or oval and *c.* $4 \times 3\,\mu$, slightly rough.
(2) Marked "*Botrytis lignifraga* Decand., Sept. 1819". Spores $4–5 \times 3–3{\cdot}5\,\mu$, very slightly rough.
(3) Germany, August 1831. Spores $3–4 \times 2–2{\cdot}5\,\mu$, smooth or nearly so.
(4) On *Polyporus squamosus*, England, 2 October 1837. Spores globoid or broadly oval, 2·5–3·5 (4) μ, apparently smooth.
(5) Nilgiris, India (*c.* 1860?). Spores oval, $2{\cdot}5–3{\cdot}5 \times 2–2{\cdot}5\,\mu$, very slightly rough.
(6) Swan River, Australia, Herb. Berk. Spores oval, $4–5 \times 3–4\,\mu$, slightly rough.
(7) Ellis and Everhart, North American Fungi 3077, collected 1893. Spores $3–3{\cdot}5 \times 2{\cdot}5–3\,\mu$.

Trichoderma viride was very common on piles of branches (mostly *Betula*) at Oxshott, Surrey, in October 1938. Many of the colonies had developed young stromata of *Hypocrea rufa*. Collections were studied in the field and laboratory, and in transfers to culture media. The characters of the spores of a few were as follows:

(1) On old *Polyporus betulinus*: spores mostly globoid, $3–3{\cdot}5\,\mu$, but some 4×3 to $5{\cdot}5 \times 4\,\mu$; slightly rough.
(2) On bark of *Betula*: spores mostly globoid, $3–5\,\mu$; a few ovoid; slightly rough.
(3) Also on *Betula*: spores 3–5 (6) $\times$ $3–4\,\mu$, nearly smooth.
(4) Cultures of *Trichoderma viride* from old *Polyporus betulinus*: spores oval or pyriform, $3–5 \times 2{\cdot}5–3{\cdot}5\,\mu$, becoming definitely roughened. Some cultures were fluffy, some with appressed growth.
(5) Culture from *Betula*: spores globoid, $3{\cdot}5–4\,\mu$, slightly rough.

Since the studies of Tulasne and Brefeld it has been accepted that the perfect stage of *Trichoderma viride* is *Hypocrea rufa*. *Trichoderma viride* can therefore be obtained in culture from ascospores, or from surface-sterilized stromata, of *Hypocrea rufa*.

Mature *Hypocrea rufa* on *Corylus*, Ranmore Common, Surrey, collected 8 October 1933, Herb. E. W. Mason no. 1283, was used in October 1933 by E. W. Mason to obtain single ascospore cultures. After some study of the cultures in the laboratory in Kew, transfers were sent to Dr McLennan, and other cultures in test-tubes were placed in a box in the laboratory. Exactly five years later (October 1938) melted agar was poured into one dried tube, and in a few days the culture was growing again. This revived culture has served the writer as a "test culture" as described below. The following notes on the mono-ascospore culture, which were made by Dr McLennan about 1933, are those of an independent and unbiased observer:

Malt agar, room temperature: mycelium hyaline, appressed; after four days some erect whitish mycelium is present and after six days small white tufts, a few of which are turning yellowish green; after nine days the tufts are coloured dark American green with some baryta yellow (Ridgway) and spores are copiously present.... Oatmeal agar: sporing tufts scattered, so that a flaky or flocculent appearance results; tufts become dull blackish green, in some cases rimmed with white; a few

are pinard yellow....Gelatine, 20°, not liquefied in first week; sporing areas whitish and colonial buff at first, then citrine to ecru olive, and later a buffy olive. After 28 days a buckthorn brown coloration is present in the medium; this deepens to dark brown....Conidiophores arise singly or irregularly grouped, length variable, simple or branched,...[bearing phialides] singly, oppositely or occasionally in whorls; phialides 6–10 μ long, 2·4–3·5 μ wide....Conidia pale green, oval, 2·5–3 × 2–2·5 μ; borne on the tips of the phialides in small heads held together by mucilage.

The single-ascospore culture revived after five years produced cultures which lacked the vigour of the original, and large tufts were no longer produced, but instead a very large number of small tufts giving a flaky appearance; the spore production was less abundant, so that the cultures were first white then a pale greyish yellowish green. The conidiophores, phialides and conidia were as recorded by Dr McLennan, except that some of the conidia reach 4 μ in length, and were measured as 2·5–4 × 2–2·5 μ. Some of the roundish heads of spores are persistent, and about 10–13 μ in diameter.

Although stromata of *Hypocrea rufa* developed in the open in abundance during late October and November 1938, they failed to mature and none was found from which ascospore cultures could be made. However, it was easy to obtain cultures of *Trichoderma viride* by taking the rufous stromata of *Hypocrea rufa*, free from overgrowth of the *Trichoderma* stage, sterilizing the surface in a solution of mercuric chloride, then crushing in sterile water and streaking out the interior of the stroma on agar. Pure cultures of *T. viride* were thus invariably obtained. These isolations varied considerably in cultural characters, but the only noticeable difference from most (but not all) cultures isolated from the *Trichoderma* stage on wood, or received from soil, etc., was a more fluffy growth of aerial mycelium that remained white for a long time, sometimes a month or two in test-tubes. But all cultures were found finally to produce the typical green or yellowish (especially in the isolation listed below as no. 3) tufts of sporulating hyphae with typical phialides and conidiophores of *T. viride*. The spore characters of cultures from a half-dozen different stromata were as follows:

(1) Spores globoid to ovoid, 2·5–3·5 μ, nearly smooth.
(2) Spores nearly all globoid 3–3·5 μ, slightly rough.
(3) Spores globoid, 3–4 μ, or oval, *c.* 4 × 3 μ, slightly rough.
(4) Spores mostly oval, 3–4 (5) × 3–3·5 μ, becoming rough.
(5) Spores mostly ovoid, *c.* 4 × 3 μ, very slightly rough.
(6) Spores 3–5 × 3–4 μ, almost smooth.

The following cultures were obtained from the collection maintained at the Centraalbureau at Baarn:

"*T. lignorum* from Richards." This culture produced usually rather small tufts, green or sometimes yellowish, with the usual phialides, and spores globoid or broadly ovoid, apparently smooth, mostly 2·5–3 μ.

"*T. Koningi*, C.B.S. strain." Spores apparently smooth, mostly 3–4 × 2–2·5 μ. Tufts conspicuous on certain media; on other media the fungus resembles closely macroscopically, and microscopically, the cultures mentioned above as revived from the mono-ascospore culture of *Hypocrea rufa*.

"*T. Koningi* from Szilvinyi." Cultures very similar to the preceding, and to those described by Dr McLennan for *T. viride* from *Hypocrea rufa*. Spores smooth, 3–4 (5) × 2·5–3 μ.

"*T. Narcissi* Tochianai & Shimada" (1931, first described by them in 1930 as *Sporotrichum Narcissi*). The cultures agree with many of those of *Trichoderma viride* obtained from wood, *Hypocrea rufa*, and soil. On Dox agar the tufts tended to remain yellowish green. The spores are globoid or broadly ovoid, slightly roughened, 3–4 (5) μ in diam. The figures of Tochinai and Shimada suggest *Trichoderma viride*, which is known to be sometimes semi-parasitic on higher plants including *Narcissus* (Gregory, 1932, W. C. Moore in litt.).

"*T. Nunbergii* Szilvinyi", 1932, from the feeding galleries of an insect in a forest. Although Szilvinyi designated this as a new species largely on the basis of its cultural characters as compared with those recorded by other workers (especially Abbott, 1926) for *Trichoderma lignorum*, *T. Koningi* and *T. glaucum*, in my view four cultures, not four species, were described. Nothing distinctive was seen in the macroscopic appearance of *T. Nunbergii* in culture. The spores are commonly 3–4 × 2–2·5 μ, smooth or slightly rough; sometimes they may be more elongate (up to 6 μ long) and may show evidence of a faint refractive guttule near each end of the spore; more elongate spores of other cultures also may show guttules. The phialides are as illustrated by Szilvinyi, and like those of *T. viride*. Chlamydospores are common.

"*Eidamia viridescens* Horne and Williamson", 1923. This has been considered by many workers to be a synonym of *Trichoderma viride* (e.g. Gregory, 1932, p. 482) but Asthana (1936) used the name "*T. viridescens*". Horne & Williamson (1923) described the fungus, and especially the cultural characters, very carefully. They were misled as to genus by a misinterpretation of the chlamydospores. I found the culture to agree with *T. viride*.

Comments and observations

It is already evident that I find the variability in morphology and in cultural characters of various isolations of *Trichoderma viride* to be such as to suggest that the names *T. Koningi* and *T. Narcissi* are synonyms of *T. viride*. The cultural characters have not been described in detail, except for the notes of Dr McLennan, which indicate the variability that may be found in a culture from one ascospore. Many

workers have described characters of cultures often probably derived from a single spore of a *Trichoderma*, and assumed them to represent a species. Milburn in 1904 described and illustrated the variation of *T. viride* in culture, and made the illuminating discovery that his culture was green on acid media, but yellow on alkaline.

I have studied the cultural and morphological characters of many scores of isolations of *Trichoderma*, and for a long time I tried to place them under the usual specific names. Bisby (with Timonin & James, 1933, 1935) reported on 337 isolations from soil in Manitoba, where this genus was found to constitute 7 % of the fungi isolated from soil. A few cultures were called *T. glaucum* and *T. album*, but 82 % were called either *T. lignorum* or *T. Koningi*. It soon became evident that all the supposed differences between these species were subject to such fluctuation that only one criterion could be made to suffice for separation of the ordinary green cultures: if the spores were mostly globoid, the culture was called *T. lignorum*; if mostly ovoid, *T. Koningi*. Even some of the "*T. album*" cultures were noted to become green on occasion. Bisby *et al.* (1935) finally expressed themselves as in agreement with H. L. Jensen (1931), who wrote of his cultures of *Trichoderma*: "Only once was a white strain found; all others were green, abundantly sporulating forms, mostly corresponding to the species *Koningi* and *lignorum*, but so variable and with so many transition forms that a sharp distinction was impossible."

Many cultures of green *Trichoderma* have been examined at the Imperial Mycological Institute; they came from various parts of the world, but were like those examined in Manitoba. Finally, in September 1938, Mr Timonin sent thirteen cultures chosen to represent variations in morphology of spores, phialides, conidiophores and tufts and in cultural characters. Mr Timonin's numbers, the source of his cultures, and his measurements of spores are as follows ("rhizosphere" refers to the layer of soil around the root of a plant):

(1)	Soil, Ottawa, Canada	3·5 × 2·5–3 μ.
(2)	Rhizosphere, Ottawa	globoid, 2·5–3 μ.
(3)	,, ,,	3·5–5 × 2·5–3·5 μ.
(4)	,, ,,	3·3–3·5 × 2 μ.
(5)	,, ,,	globoid 2–3·5 μ.
(6)	,, ,,	globoid 2–3·5 μ.
(7)	,, ,,	3·5–5 × 2·5–3 μ.
(8)	,, ,,	4–4·5 × 2–3 μ.
(07)	From Dr Weindling, U.S.A.	globoid 3·3–5 μ.
(28)	Cotton roots, Texas, U.S.A.	globoid 2·5–3·5 μ.
(58)	,, ,, ,, ,,	globoid 2·5–3·5 μ.
(67)	,, ,, ,, ,,	3·3–4·5 × 2·5–3 μ.
(68)	,, ,, ,, ,,	globoid 3–3·5 μ.

Tests were made with these cultures in comparison with:

T. The "test culture" from a single ascospore of *Hypocrea rufa*.
T 6. A "test culture" from stroma 6 (see above) of *Hypocrea rufa*.
L. *Trichoderma lignorum* from Richards via C.B.S.

KC. *Trichoderma Koningi*, C.B.S. culture.
KS. *Trichoderma Koningi*, from Szilvinyi via C.B.S.
Nar. *Trichoderma Narcissi* from Tochinai and Shimada via C.B.S.
Nun. *Trichoderma Nunbergii* from Szilvinyi via C.B.S.
E. *Eidamia viridescens* from Horne and Williamson via C.B.S.
A. *Trichoderma* from Wattle bark, South Africa.
W. *Trichoderma* from mushroom bed, England, isolated by Dr Ware.
G. From *Hypocrea gelatinosa* (see below).
P. From *Hypocrea pulvinata* (see below).

These various isolations (excluding G. and P.) were grown on clear maize-meal agar in Petri plates, four isolations at random on each plate. There were only minor differences in macroscopic appearance, and the hyphae invariably intermingled slightly when two adjacent colonies met, then both stopped growth. Similar inoculations were made upon richer media, including potato dextrose agar and prune agar. On these media the cultures varied more in appearance, made more luxuriant growth and more overgrowth of hyphae at the line of contact between any two mycelia; but showed no evidence of mutual aversion (see Miss Cayley, 1923) or of parasitism. I did not find any basis for specific difference in the cultural characters.

Hyphal fusions have been considered a possible criterion for distinguishing species of fungi (see Buller, 1931; Matsumoto *et al.* 1932). Hyphal fusions occur commonly in a culture of *Trichoderma*, as Buller showed. The occurrence of fusions between hyphae of the various "strains" was investigated by using the technique of Matsumoto *et al.* (1932), by watching the hyphae from spores placed near each other in Petri dishes, and by cutting out strips of agar between two advancing colonies in Petri dishes to force the hyphae to meet on the surface of the glass. Only what seemed clearly to be "true fusions" were accepted. Every possible combination between the twenty-five cultures was not attempted by this tedious process, but first each culture was tested against T. in at least two tests. The following fusions were observed: T. with 1, 3, 4, 6, 8, 07, 28, 58, T 6, L., KC., KS., Nar., E., and A. For one reason or another fusions were not definitely seen between T. and the cultures not mentioned. These were tested with other strains, and fusions were found between T 6 and 2, 5, 28, T., Nun., KC., W., and G.; between KC. and L., 67 and W.; between G. and Nun., T 6, KC., and E.; between 68 and 2; between 8 and 7. Fusions were not found between P. and other cultures tested.

These hyphal fusions support the view, gained from study of the morphological and cultural characters, that the various cultures of *Trichoderma* represent one variable species.

The bases for separating the so-called species just considered will now be examined.

T. Narcissi: no reason given by the authors for considering it

distinct from *T. viride*; no reason is found in the description or in the characters of the culture, and hyphal fusions readily occur with *T. viride*.

T. Nunbergii: supposed cultural differences between this and *T. viride*, *T. Koningi* and *T. glaucum* are given by Szilvinyi, the spores are cited as $3{\cdot}3 \times 2{\cdot}2\,\mu$, and the fungus was found in an insect gallery. None of these points provides a definite basis for a new species. The cultures show spores sometimes unusually elongate (i.e. the fungus might be *T. Koningi* if that be distinct).

The name *T. Koningi* is so firmly entrenched in the literature of thirty-seven years that it requires special attention. Oudemans distinguished it by "elliptic" spores $3–4 \times 2{\cdot}5–3\,\mu$, in heads $8–10\,\mu$, whereas *T. viride* he interpreted as having spores "absolument globuleuses, plus petites, réunies en glomérules dont le diam. ne dépasse pas $5{\cdot}7\,\mu$". Apart from these possible points of difference one finds nothing in his description or figures to exclude *T. viride*. *T. Koningi* had woolly tufts first white then green, and the figures of phialides and chlamydospores would pass excellently for those of *T. viride*. Subsequent workers soon found that the suggested difference in size of spore clusters was imaginary, and the pages preceding this show that there was evidently no significance in the minute differences in shape or size of spores suggested by Oudemans: the ascospore culture from *Hypocrea rufa* has the spores of "*Trichoderma Koningi*", other specimens or cultures of *T. viride* have spores from globose to more "elliptical" than $3–4 \times 2{\cdot}5–3\,\mu$, and the spores may be larger. But a confusing series of other presumed differences has been suggested by subsequent workers, e.g. colonies floccose and conidiophores up to $25\,\mu$ long in *T. Koningi*, colonies tufted and conidiophores up to $70\,\mu$ long in *T. viride*; differences in amount of mucus or shape of phialides. These points hardly need be discussed: the floccose or tufted appearance, the amount of mucus, and even to some extent the shape and length of the phialide, vary with the individual and with the conditions of culture. As for the length of the indefinite conidiophore, it may bear one phialide or ramify through a tuft, so that $10–1000\,\mu$ more accurately expresses the length. On the other hand, Duché & Heim (1931) record globoid spores up to $2{\cdot}5\,\mu$ for what they called *T. Koningi*, Miss Niethammer (1937) roundish spores for *T. Koningi* and ellipsoid for *T. viride*, and Stevenson & Rands (1938) give the spores of *T. Koningi* as $3{\cdot}2–4{\cdot}8 \times 1{\cdot}8–3\,\mu$, of *T. lignorum* as $3{\cdot}8–5 \times 2{\cdot}5–3\,\mu$.

I have found no basis for separating from *T. viride*, even as varieties, *T. Narcissi*, *T. Nunbergii*, and the description of *T. Koningi* and cultures attributed to the name (type material of *T. Koningi*, if kept, I have not seen). Hyphal fusions occur between the various cultures. When all is said, *T. viride* is not even surprisingly variable; the part-spores of its perfect stage are (Petch, 1938) "globose $3{\cdot}5–4{\cdot}5\,\mu$,

or oval, 5–6 × 3·5–4 μ", and one may expect the conidia of a species to vary as much as its ascospores.

I have conscientiously sought other possible criteria for distinguishing species or varieties of *Trichoderma*. There is the point of minutely roughened spores, mentioned for *T. viride* by Miss Dale (1914) and Petch (1938). But higher powers of the microscope show most spores, or might show all, to bear a slightly roughened surface. I have not ascertained the nature of the inconspicuous roughening of the spores (they are usually recorded in the literature as smooth). The roughness might conceivably be due to the slime accumulated in patches, but ether does not remove it.

A few tests were made with cultures on media made alkaline by the addition of dilute potassium hydroxide. Milburn found his culture to be yellow in certain alkaline media. Horne & Williamson (1923) found the growth limits to be *p*H 2 and 8·2. My tests were inconclusive: some strains produced no tufts, some yellowish, some greenish tufts. The striking thing was the retardation of growth; colonies after 13 days were only 10–35 mm. in diameter. Bisby *et al.* (1935, p. 56) report that they failed to isolate *Trichoderma* from an alkaline soil.

The maximum temperature for the various strains of *Trichoderma* was found to be 35 to about 38° C. (see also Bisby *et al.* 1935, p. 63). At temperatures of 20–30° C. growth is rapid, but varies with the individual culture and with the medium.

The great variation in the appearance of cultures can be demonstrated by anyone who will make transfers of one culture to various media, including one with high sugar content and one with an alkaline reaction.

The odour of cultures of *Trichoderma* was recorded by Vuillemin as camphorated and by Horne and Williamson as that of coconut oil. About a dozen people were asked (without a suggestion as to what the odour had been called), and the majority soon said "coconut" or "coconut-cakes". No one had another definite suggestion. This odour is often very marked on certain media (including prune agar and potato-dextrose agar). The six cultures mentioned above as isolated from *Hypocrea rufa* all had the odour at first, but three soon lost it. The cultures of "*Eidamia viridescens*", however, still have the odour after sixteen years in culture. Most isolations from soil lack the odour.

In looking carefully at phialides, it was noted that the spores were sometimes in chains of a few to about a score of spores. This seemed an excellent character for distinguishing species. However, Tulasne, and Horne & Williamson had mentioned but not illustrated spores in chains in *Trichoderma viride*, and a figure by Oudemans seems to show a chain of spores which he did not mention for *T. Koningi*—and careful examination of most of the various cultures of *Trichoderma* showed

the occurrence of some spores in chains, the longer chains occurring with more globoid spores (Fig. 3). The physical conditions requisite for the production of chains were not ascertained, but they developed best under damp conditions. Of course, the spores in *Trichoderma* are

Fig. 2. Semi-diagrammatic figures to show the development of phialides and spores in *Trichoderma*. The young phialide lacks a firm wall, but this develops from below upward. A septum (no doubt perforated by a pore) is formed at the base as the phialide matures. The initial of the first spore is evident early. This spore becomes cut off at the neck of the phialide, and successive young spores are pushed out. The spores usually accumulate in a cluster held together by slime. See Vernon, *Ann. Bot.* XLV, 736, fig. 2, 1931, for development of spores.

Fig. 3. Sketched from various cultures of *Trichoderma viride*, mostly on agar on slides in a damp chamber. The spores sometimes develop in chains, are roundish or oval, sometimes evidently roughened. The spores from two or more phialides may form a common cluster.

normally formed in heads and upon drying may be held together rather persistently by a slimy substance. Sometimes the heads of spores from two or three phialides may combine. This association of slime with spores is an important character (see Mason, 1937). It precludes the spread of spores by air currents, in the laboratory at least. The tufts of spores of *Trichoderma* are often recorded as

"powdery", but it is a damp powder very different from the dust of a dry-spored fungus such as *Penicillium*.

I believe I have shown that the common green *Trichoderma* constitutes one somewhat variable species, and that mycologists from 1829 to 1902 were right in so considering it. The use of culture media tempted some workers to describe species on cultural and morphologic characteristics that are inadequate when a wide range of specimens is studied.

Fig. 4. *Trichoderma viride*, copied from Tulasne, 1865, the right-hand portion of fig. 7, pl. III, vol. III.

Description

The genus *Trichoderma* Pers. ex Fr. is distinguished by considering in conjunction these macroscopic and microscopic characters: tufts or cushions of hyphae normally appear on natural substrata or in artificial culture; the tufts are composed of conidiophores, many spores and some sterile hyphae; conidiophores indefinite, consisting of an unbranched or branched hypha, bearing phialides laterally and terminally; phialides surmounted by heads (rarely by short chains) of sliine spores; spores hyaline or brightly coloured under the microscope, one-celled.

Trichoderma viride *Pers.* (1794 *et post*) *ex Fries* (1829)

Fries and others cite several early names as synonyms. I have not attempted to verify these.

Trichoderma lignorum (Tode) Harz (1871).
Acrostalagmus viridis (Pers. ex Fr.) Vuill. (1887).
Trichoderma Koningi Oudem. (1902).
Eidamia viridescens Horne & Williamson (1923).
Sporotrichum Narcissi Tochinai & Shimada (1930).
Trichoderma Narcissi Tochinai & Shimada (1931).
Acrostalagmus Koningi (Oudem.) Duché & Heim (1931).
Trichoderma Nunbergii Szilvinyi (1932).
T. viridescens (Horne & Will.) Asthana (1936).

Spreading vegetative hyphae usually not conspicuous in the field, but in culture they form quickly and grow rapidly into main hyphae about 10–12 μ in diameter, tapering to 2 μ in the smaller branches; septa about 25–100 μ or more apart; these vegetative hyphae usually form a thin, inconspicuous growth on media with little organic food, but usually form a fluffy growth on richer media, white or whitish, medium uncoloured or turned yellowish or brownish, odour of cultures sometimes of coconut. Chlamydospores are formed on natural substrata or artificial culture, sometimes within a day or two in culture, sometimes only after several days, globoid or oval, terminal or intercalary, mostly 7–14 μ in diameter. Tufts in "Hoch-Kultur" first white, commonly 1–5 mm. in diameter, *c.* 1 mm. high, sometimes becoming yellowish, golden or brownish, but usually soon becoming green first within (and surrounded by uncoloured, branched hyphae), then the greater part of the tuft becomes green throughout, with different shades of green corresponding roughly to the varying shades of green leaves. The tufts may sometimes remain white or yellowish, or they may even be almost absent. Conidiophores not sharply distinct from the vegetative hyphae from which they arise, sparingly to abundantly branched, the branches arising at approximately 90° from the parent hypha or portion of conidiophore. Phialides rather distinctive, nine-pin shaped (narrowed at the base and more so above), 8–15 (20) μ long, 2–4 (5) μ wide at the centre, arising singly or opposite or in whorls seldom of more than three phialides, each soon surmounted by a head of about five to thirty or more spores held together by slime; heads often rather persistent, 7–15 μ in diam., subglobose; chains of spores sometimes produced. Conidia arise by the extrusion of protoplasm through the neck of the phialide; each conidium after becoming provided with a firm wall is cut off, and is usually held by surface tension near the apex of the phialide; conidia globoid and 2·5–4 (5, rarely 6) μ in diameter or oval and 3–4 × 2·5–3·5 μ, more rarely sub-elliptic and 4–5 (6) × 2–3 μ, range 2·5–5 (6) × 2–4 (5, rarely 6) μ, pale bright green under the microscope, one-celled, contents granular, wall thin, smooth or commonly marked with inconspicuous roughenings about 0·5 μ apart; on germination the conidia swell to globoid form and 6–9 μ diam., producing hyphae which anastomose readily.

Commonly found fruiting on dead wood or stems, where it often develops into *Hypocrea rufa*; occasionally somewhat parasitic to higher plants in dormant or weakened condition; abundant in the soil, where it is important in decomposing organic material and in parasitizing other fungi; widely distributed over the world.

Fungi related to *Trichoderma viride*

Early mycologists, who considered *Trichoderma* to be a Gasteromycete and who relied largely on macroscopic characters for diagnosis, evidently placed certain Myxomycetes, the sporodochia of fungi, etc., in *Trichoderma*. Recent mycologists, who rely largely on

microscopic characters, have placed *Trichoderma* as *Acrostalagmus* and *Sporotrichum*, and *Pachybasium* as *Trichoderma*. *Pachybasium* is separable because the conidiophores have sterile apices and conspicuous tufts are not formed. *Acrostalagmus* (and *Verticillium* if distinct from *Acrostalagmus*) differs from *Trichoderma* principally in macroscopic characters, but possibly also in the more definitely verticillate arrangement of the phialides. *Sporotrichum* does not have heads of slime-spores.

It is especially noteworthy that *Trichoderma viride* can produce spores in chains, that the spores from more than one phialide often combine into a common cluster, and that, in a saturated atmosphere, the phialides may become more elongate than usual. In these respects relationship with *Gliocladium* is shown.

Other names in *Trichoderma*

The writer would interpret *T. glaucum* Abbott, from the description, as *T. viride* in the not uncommon yellowish condition, which Milburn found could be induced by an alkaline medium. *T. nigro-virens* Goddard seems uncertain, and unless type material can be examined the name might be discarded. The several older and still more doubtful names in *Trichoderma* also require examination of type material if available, or discarding if there is no type. It seems obviously unlikely that species of *Trichoderma* can be present in Europe or North America and have been collected but once.

The only type specimen of a *Trichoderma* in Herb. Kew. is that of *T. lateritio-roseum* Lib. in Cooke, *Grevillea*, VIII, 83, 1880, on rotted potato tubers. An examination of the specimen shows sporodochia; Cooke saw the microconidia but overlooked the macroconidia of *Fusarium* which are also present. The name must be discarded.

I consider *Trichoderma* to be a monotypic genus.

Hypocrea gelatinosa (Tode ex Fr.) Fr. and its conidial stage

Sphaeria gelatinosa Tode was described in 1791 in *Fungi Mecklenb.*, which also includes the "Pyrenium" now called *Trichoderma viride*. Tulasne, 1865, p. 30, states: "*Sphaeria gelatinosa* Tode, which is exactly analogous to *Hypocrea rufa* Fr., seems to have been known to Tode himself as being of a double nature." *Sphaeria gelatinosa* was accepted in the *Systema*, but Fries later transferred it to *Hypocrea*. Seaver (*Mycologia*, II, 58, 1910) made it the type of his genus *Chromocrea*, "distinguished from *Hypocrea* by the colored spores".

Brefeld (1891) reported the conidial stage of *Hypocrea gelatinosa* to be like the *Trichoderma viride* he obtained from ascospores of *Hypocrea rufa*, and states "Fig. 57 kann auch für *H. gelatinosa* gelten". It is true that he gave the conidia from the latter as $5 \times 4\,\mu$, those from *H. rufa* as

globular, 2–2·5 μ, but both measurements could, as he thought, represent *Trichoderma viride*. The conidia of both were greenish. Brefeld mentions a stromatic layer formed in cultures from *Hypocrea gelatinosa*.

Milburn (1904) reported briefly on a culture of *Trichoderma* obtained from what he thought to be *Hypocrea gelatinosa*, and gives only minor differences between it and *Trichoderma viride*.

Vincens (1917) studied what he considered to be *Hypocrea gelatinosa*, particularly the development of asci and perithecia. He found stromata in a wood in late February, pulverulent from the conidial stage, which his illustration shows had phialides and spores like those of *Trichoderma viride*. He found that the spores from a small cluster of phialides united into a common head. He does not report cultures. Vincens states: "Tandis que les coussinets conidifères de l'*Hypocrea rufa* verdissent au moment de la formation des conidies, ceux de l'*H. gelatinosa* ne dépassent jamais une teinte légèrement ochracée tant que les conidies se forment." Stromata placed in a damp chamber in the laboratory developed the conidial stage so abundantly as to arrest the development of the perithecia.

In reality, neither Brefeld, Milburn, nor Vincens found adequate reason for distinguishing the conidial stage of *H. gelatinosa* from that of *H. rufa*. A well-known American mycologist also has remarked recently in a letter that he obtained what appeared to be *Trichoderma viride* in cultures made from *Hypocrea gelatinosa*.

Stromata, appearing typical of *H. gelatinosa*, were collected by Miss K. Sampson (of Aberystwyth) in the autumn of 1933 and sent to E. W. Mason, who made isolations from ascospores. Several cultures of the resulting conidial stage, after preliminary study, were placed in a box in the laboratory. Five years later melted agar medium was poured into one of the dried tubes, and as in the culture from *H. rufa*, the fungus promptly revived.

This conidial stage produced spores 3–4 × 2·5–3·5 μ, and in every respect agrees with *Trichoderma viride*. It was studied very carefully in a search for distinguishing characters, and many of the details regarding *T. viride*, such as the production of spores sometimes in chains, were actually first observed in the culture from *Hypocrea gelatinosa*. It even produces the coconut odour characteristic of many cultures of *Trichoderma viride*, and hyphal fusions readily occur with hyphae from *T. viride*. Older cultures formed the yellow stromatic development recorded by Brefeld—but so did certain cultures isolated from stromata of *Hypocrea rufa*. No perithecia or asci were found in any culture of *H. gelatinosa* or of *Trichoderma viride*. Miss Niethammer (1937) found a perithecium in a culture she called *T. Koningi*, but its identity is doubtful.

The problem involved here, i.e. the formation of the same conidial

stage by two species which some place in separate genera, can only be solved by further study of the *Hypocrea* stages, and more cultures. An examination of the numerous collections in Herb. Kew. suggests that *H. gelatinosa* is only a growth form or mature condition of *H. rufa*. Many specimens at Kew marked *H. gelatinosa*, including Fries Scler. Suec. 304, do not appear to me to be distinguishable from *H. rufa*, nor many marked *H. rufa* from *H. gelatinosa*. Tulasne (1865) says, of the cushions of *H. rufa*, "a very few...become at length dark-aeruginous".

An effort was made to follow to maturity the development of stromata of *H. rufa* during the autumn and winter of 1938–9. Specimens placed in a damp chamber merely produced masses of conidiophores of *Trichoderma*, as Vincens found for *Hypocrea gelatinosa*. If kept saturated, some stromata became gelatinous, but did not mature asci. (Horne & Williamson found that the mycelium of *Trichoderma viride* may become gelatinous.) Specimens left in the wood or placed in a garden reverted to *T. viride*, which the rain gradually washed away.

Hypocrea pulvinata Fuckel and its conidial stage

Hypocrea pulvinata (with several probable synonyms) is commonly found on old *Polyporus betulinus*. Cultures were made by E. W. Mason in 1933 and sent to Miss McLennan, and fresh cultures were made by me from stromata collected at Oxshott in October 1938. The fungus is homothallic, and cultures from a single half-ascospore or single conidium soon produce mature stromata with abundant ascospores.

The conidial stage in culture consists of phialides 25–40 μ long, or often reaching 75 μ or more; they develop singly from the vegetative hyphae or several may come from a single hypha making it an indefinite conidiophore. The shorter phialides are provided with a septum at the base only, the longer ones with an additional septum or two (in which case only the terminal cell should probably be considered the phialide); the phialides soon produce slime-spores at the apex and the spores gather into clusters. The spores are hyaline, one-celled, variable in size, often globular and 3–8 (10) μ in diameter, sometimes pyriform or oval. The fungus makes a thin spreading growth on the culture media used, and soon produces whitish patches or areas of conidial production, followed by the development of roundish or oval yellowish stromata mostly 2–5 mm. wide, often confluent; the stromata in culture are like those in the field.

The conidial stage is probably best referred to *Cephalosporium*. It approaches *Trichoderma* in the formation of patches, but no tufts as definite as those formed by *T. viride* were seen in culture, and the

phialides are also indefinite. I have not observed the conidial stage out-of-doors. Dr McLennan went through the literature of *Cephalosporium*, and suggests that *C. macrocarpum* Corda, described on old *Polyporus*, may represent this conidial stage. Ruhland (1900) figured the conidial stage of *Hypocrea fungicola* (perhaps a synonym of *H. pulvinata*) but did not name it.

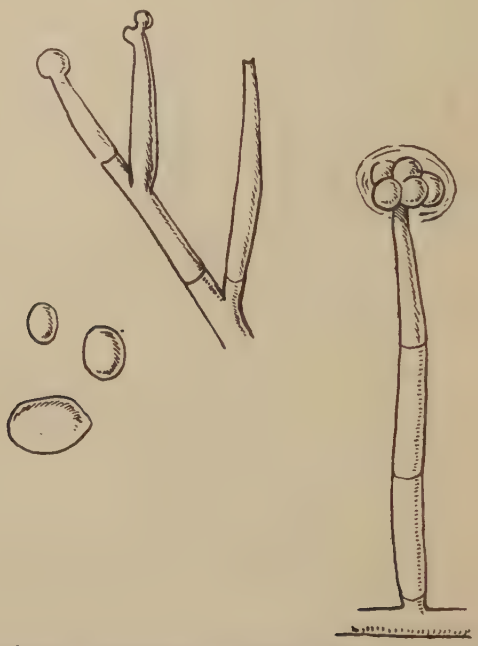

Fig. 5. The conidiophores and conidia of *Hypocrea pulvinata*. The phialides may arise singly, or may develop successively to form indefinite conidiophores. The spores are variable. (Figs. 2–5 redrawn by Mrs G. R. Bisby.).

Transfers of the single-ascospore culture of *H. rufa*, T 6 from a stroma of *H. rufa*, the ascospore culture of *H. gelatinosa*, and a single half-ascospore culture of *H. pulvinata* have been sent to the Centraalbureau at Baarn, the National Collection of Type Cultures in England, and to the American Type Culture Collection. The other cultures mentioned above are being kept (dried) at the Imperial Mycological Institute, but should be available for some time to anyone who wishes to restudy *Trichoderma*.

Summary

Trichoderma viride Pers. ex Fr., the conidial stage of *Hypocrea rufa*, has been known since about 1790. Persoon's specimens, other specimens from herbaria or the field, and cultures from *H. rufa*, soil,

etc., show the fungus to be variable. The most noteworthy variable character is the shape of the conidia, which are subglobose in some isolations, ovoid in others; but the same variation is found in the shape of the ascospores. The name *Trichoderma Koningi*, based principally on the oval shape of the conidia, is considered untenable for various reasons. A single ascospore culture of *Hypocrea rufa* produced conidia as described for *Trichoderma Koningi*. *T. Narcissi* and *T. Nunbergii* do not differ from *T. viride*.

T. viride was obtained from ascospores of a specimen determined as *Hypocrea gelatinosa*. Brefeld and others have reported the same result. It is suggested that *H. gelatinosa* is only mature *H. rufa*.

Hypocrea pulvinata produces a conidial stage considered to belong to *Cephalosporium*. It is homothallic, and readily forms ascospores in culture.

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NOTE ON AN ABNORMAL FUNGUS ON BIRCH

By W. P. K. FINDLAY, M.Sc.

(With Plate III)

During the Autumn Foray of 1938 an interesting abnormal fungus was collected on a birch tree growing near Aviemore station (Inverness-shire). It consisted of a large coal black mass about 30 cm. across. It was very much cracked and extremely hard and brittle, its general appearance suggesting a large clinker (see Pl. III, fig. 1). On breaking off a piece, the interior was seen to be dark reddish to yellowish brown, only a very thin external layer being carbonaceous. No sign of any fertile layer was found on the fungus.

Cultures were easily obtained from the internal tissue. These grow readily on malt agar, and in diffuse light soon develop a pore layer on which basidia and spores are produced. These basidiospores are hyaline or faintly yellowish, and measure 8–10 × 4–5 μ. Dark brown thick-walled bulbous setae occur in the hymenium. This fungus is undoubtedly identical with that described by Katayevskaya (1928), as the "Tchaga" fungus which occurs on birches in Russia, and which she suggested was a form of *Fomes igniarius*. It is also identical with a fungus recently described by Campbell & Davidson (1938), who found it associated with a species of *Poria*, which they suggest is one of the *P. obliqua* (Pers.) Bres. group.

Pl. III, fig. 2 shows a culture of the birch fungus alongside a culture of *Fomes igniarius*. It will be seen that they differ in many respects, the colour of the cultures also is quite different. That of *F. igniarius* is a uniform deep reddish brown (Mars Yellow to Sudan Brown),* while that of the birch fungus is generally pale fawn (Buckthorn Brown). The spores of the birch fungus are considerably larger than those of *F. igniarius*, and their size agrees closely with that given for *Poria obliqua* (*Xanthochrous obliquus*), by Bourdot & Galzin (1927).

It therefore appears probable, that the Aviemore fungus is related to *Poria obliqua*, which is sometimes described as forming amorphous masses (Bourdot & Galzin), and which has been reported from birch in Sweden.

It is hoped that further search will discover some fertile fruit bodies associated with the abortive fungus which occurs on the birch in Scotland, and that examination of these will lead to a more definite determination of the identity of the fungus.

* Ridgway colours.

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EXPLANATION OF PLATE III

Fig. 1. Abnormal fungus at base of birch tree near Aviemore.
Fig. 2. Cultures on 5 % malt agar of (*a*) *Fomes igniarius* (Linn.) Fr., (*b*) the fungus from birch.

(*Accepted for publication* 16 *March* 1939)

Fig. 1.

(*a*) (*b*)

Fig. 2.

STUDIES IN THE GENUS *USTULINA* WITH SPECIAL REFERENCE TO PARASITISM

V. A DISEASE OF ELM (*ULMUS CAMPESTRIS* SM.) CAUSED BY *USTULINA*

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(With 5 Text-figures)

I. Introduction

This paper is a continuation of the studies on the pathogenic powers of *Ustulina vulgaris*. The previous paper on *Ustulina* disease of lime by Wilkins (1936) was the first detailed, experimental account of the fungus causing a wood rot of timber in temperate climates, and, in order to avoid repetition, frequent reference will be made to that paper.

I have twice encountered an *Ustulina* disease of elm but on only one of these occasions was material available for investigation. This scarcity of instances must be ascribed to the fact that the disease, as affecting standing timber in temperate regions, has only recently been brought to notice, rather than as an indication of the relative infrequency of the disease. It is nevertheless interesting that elm has only twice been quoted as a host on which fructifications of this fungus have been found. The first record was by Tulasne (1863) from France and the second was by Lind (1913) from Denmark.

The elm tree dealt with in this paper was felled near Princes Risborough during clearing operations and my thanks are due to K. St G. Cartwright, M.A., of the Forest Products Research Laboratory for notifying me of the diseased condition of the tree.

II. Preliminary examination of the tree

The tree appeared to be a fine specimen and while standing, showed no external symptoms of disease. It was not obviously wounded or damaged in any way and there was a complete absence of fungus fructifications. When felled, however, it was found that the base of the trunk was rotten in the centre, and the general appearance of the diseased stem and roots suggested a typical case of *Ustulina* disease. This absence of external symptoms of disease is an important feature for, though this tree was not actually dangerous, it is reason-

able to assume that eventually it would have been and, moreover, from the standpoint of the timber merchant who bought it as a sound tree it was a very unprofitable transaction.

III. Isolation of the causal organism

Sterile borings from the stem and roots—more particularly from the diseased regions—produced pure cultures of *Ustulina vulgaris* and, as no other fungus could be isolated, it was assumed that this species was the pathogen responsible for the disease. The identity of the causal organism was subsequently confirmed, as in the lime disease, with the exception that, here there were no fructifications and hence all deductions had to be based on cultural and microscopic comparisons and reinoculation experiments.

IV. More detailed examination of stem and roots

The trunk was cut up into sections as follows:

No. of section	1	2	3	4	5	6
Height above ground level	1 ft. 6 in.	3 ft. 6 in.	5 ft. 6 in.	7 ft.	8 ft. 6 in.	10 ft. 6 in.

The roots of the tree were also dug up but as the excavators desired to get them out of the way as soon as possible they were too broken up to be sectioned like the stem and only one complete section could be cut—at a distance of about 1 ft. from the trunk.

In both stem and roots the infected regions showed a peripheral region of sound wood, inside that a more or less concentric zone of dark-coloured wood, while the centre was occupied by an area of quite obviously diseased wood. The cross-section of elm differs from that of lime by the presence in the former of a naturally dark-coloured heart-wood which is absent from lime. As this heart-wood is not primarily discoloured by fungus action and, as ascertained later, does not appear to be affected by the fungus outside the black line delimiting the diseased area, and as the peripheral so-called "sound wood" is the normal sap-wood, the three types of wood will be referred to respectively as: (*a*) sap-wood, (*b*) heart-wood, and (*c*) diseased wood.

The relative distribution of these three types of wood as seen at different levels in the stem cross-sections is illustrated in Fig. 1, diags. 1–6.

Borings were taken, after sterilizing the surface, at regular intervals along radii passing through all three types of wood but cultures of *Ustulina* were obtained only from the diseased wood.

The heart-wood of the elm was darker than the discoloured wood of the lime. It was paler on the margin where it bordered on the sap-wood, whereas the discoloured wood of the lime was distinctly

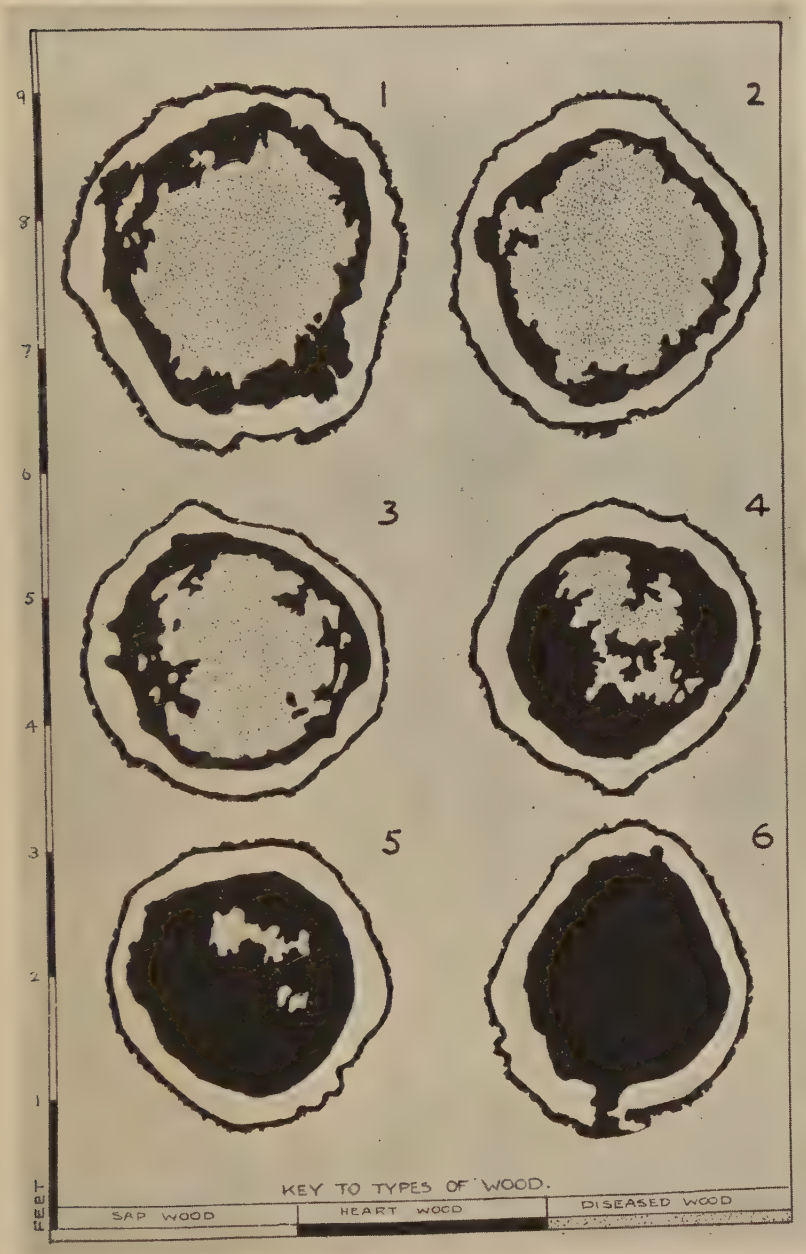

Fig. 1. Cross-sections of the trunk to show the distribution of the diseased wood.

bordered by a darker zone on the outer margin, and the dark colour of the elm heart-wood tended to follow the annual rings while the discoloured wood of the lime did not. All three types of wood were seen in sections 1–5, but, as the sap-wood and the heart-wood are normally representative of sound timber, only the extent and distribution of the diseased wood need be discussed.

In general appearance the diseased wood was superficially identical with that of the lime, being of light colour and brittle texture. The regional distribution of this type of wood, as shown in Fig. 1, shows that, on the whole, and particularly in the lower sections, it tends to be restricted to the centre. As there was no wound at the side of the trunk of the tree, the spread of the mycelium was not lateral from one point of infection (as was suggested in the lime) but appeared to be more or less radial from one or more points of infection at the base of the tree. In the uppermost sections of the trunk, the area of the diseased wood was less concentric and more irregularly distributed, sometimes leaving isolated patches of heart-wood within its circumference and sometimes itself occurring as "islands" in the heart-wood outside the main diseased area. This latter arrangement was specially marked in the roots, where the diseased wood seemed to extend from the trunk in an irregular finger-like manner. Disease was invariably confined to the heart-wood and never penetrated out to the sap-wood, but it extended up the trunk for a distance of about 10 ft. and into the roots for about 3 ft.

The black line, characteristic of this type of disease, was less obviously distributed throughout the diseased wood than it was in the lime, but it was typically present round the periphery of this wood where it formed a very definite and relatively wide line of demarcation between this and the sound heart-wood. This line which, in the lime, was apparent only after drying out, was very evident in the freshly cut elm timber. This point was particularly noted, as other observers, for example Hubert (1931), have commented on the fact that the black line appears only when the wood dries out. It was invariably present in every transverse section, and longitudinal sections showed that it existed as a sheath, delimiting the margin of the diseased wood, all through the stem and roots.

V. Microscopic examination of the timber

Sections were cut, either freehand, or with a wood-cutting microtome, of the three sorts of timber. They were examined both stained and unstained. As in the lime, Cartwright's (1929) stain was used to determine delignification, and again this stain was found to give the clearest microchemical indication of the progress of the decay. The drawings were made with the aid of a Leitz projection apparatus.

(*a*) *The sap-wood*

The sap-wood was examined first. The wood-parenchyma cells were filled with starch (March) and there was a small amount of starch also in the cells of the rays. The walls were uncoloured (in unstained sections) and none of the cells contained infiltration products. No hyphae were found in this wood, and it was not examined further.

(*b*) *The heart-wood*

The heart-wood is to be regarded as converted sap-wood, and, as no hyphae were found in the heart-wood, the changes from sap-wood to heart-wood can be considered as normal and non-pathogenic. In spite of the absence of hyphae outside the black line, the structure of this wood is interesting as it forms the basis of decay by fungal hyphae, and conversion from sound heart-wood to completely decayed wood can be traced. In the heart-wood, some of the wood-parenchyma cells have lost their starch and contain, in its place, a light brown substance and dark brown granules of about the same size as starch grains; in certain of the cells, however, starch still remained. All the starch had disappeared from the cells of the rays though all the cells contained the brown substance; the dark coloured granules were found in some of the cells, presumably those which had originally contained starch. These granules are dark even when unstained and they are not further stained on treatment with iodine. Schrenk (1903, p. 14), in describing a disease of the white ash caused by *Polyporus fraxinophilus*, found that starch grains in rays and wood-parenchyma disappeared, a fact which he attributed to the action of enzymes secreted in advance of the fungus. After the disappearance of the starch the cells were filled with a brightly coloured substance which he regarded as a decomposition product of starch. He stated that these decomposition products were soluble in alkalis. The brown substances found in the heart-wood of the elm, when so tested, were found to be insoluble. This would suggest that, even if in both the heart-wood of elm and the discoloured wood of lime, the products were the result of starch decomposition, they were not identical in composition. In other words, in connexion with rays and wood-parenchyma, the final products of starch decomposition which result from the pathogenic influence of the fungus are not the same as those produced naturally by normal conversion to heart-wood.

The heart-wood of elm owes its dark colour to the presence of these decomposition products in the wood-parenchyma and the rays. The rays of elm are very numerous and conspicuous and are alone sufficient to give a pronounced brown to the cross-section. In contrast to the state of affairs found in the lime, the vessels and fibres appear to be completely free from any sort of infiltration.

There is then a marked difference between the natural heart-wood of elm and the "false" heart-wood of lime (usually referred to as the "discoloured wood") which can be summarized as follows:

(i) In the elm, the red-brown colour is due to the infiltrations present in the cells of the wood-parenchyma and the rays; there is no infiltration of the non-living elements, e.g. vessels and fibres; the cell walls are uncoloured.

(ii) In the lime, the brownish colour is due to the infiltrations of the non-living elements, e.g. the vessels and the tracheids, as well as to the coloured walls of the cells; there is no infiltration of the living elements such as rays and wood-parenchyma.

(*c*) *The diseased wood*

The diseased wood was absolutely delimited by the black line, and the distinction (which was quite obvious to the naked eye) between heart-wood on the outside and diseased wood on the inside of the line was found, by microscopic examination, to occur sharply at the line. The wood outside the line showed no sign of decay; on the inside, however, the whole area was decayed though there was considerable local variation in the degree of structural disintegration of the wood elements.

(i) *The effect of the fungus on the timber.*

In order fully to appreciate the effect of the fungus mycelium in producing decay it is desirable to outline briefly the organization of the sound wood and compare it with the disorganization caused by fungus action. This comparison is illustrated in Fig. 2, where *A* represents sound and *B* represents diseased wood respectively.

The individual annual rings are so consistently alike that a description of one ring is sufficient. Each ring, as seen in transverse section, consists of:

(*a*) A narrow zone of very large vessels forming the pore ring of the spring wood. These vessels tend to be separated from each other, the intervening space being occupied by the wood-parenchyma.

(*b*) A much wider zone of summer wood, consisting of groups of vessels tangentially arranged in undulating and discontinuous bands. The vessels decrease gradually in size as the groups become more distant from the spring wood of that ring. These bands of vessels alternate with bands of fibrous tissue, which are composed mainly of fibres but have some admixture of tracheids. As from our present standpoint, no anatomical distinction between these two types of element is necessary, these will be referred to collectively as "fibres".

(*c*) The rays cut the ring into radial strips about 50 μ wide. They are from one to six cells in width.

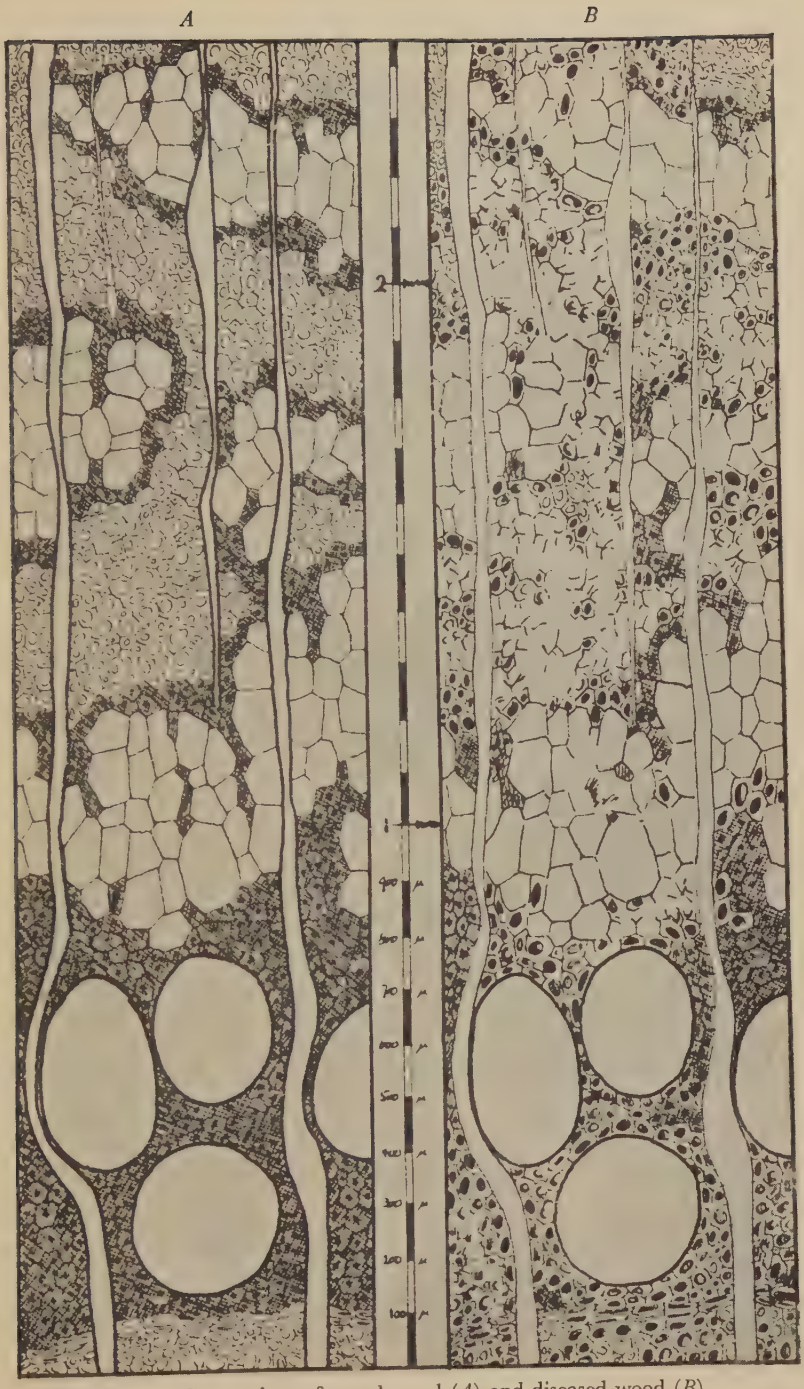

Fig. 2. Comparison of sound wood (*A*) and diseased wood (*B*).

(*d*) The wood-parenchyma is generally abundant and vasicentric in relation to the large vessels of the spring wood. It is also found in connexion with the groups of vessels of the summer wood, particularly where these border on the fibres at each end.

From Fig. 2*B*, which shows the subsequent disintegration of the sound wood, it will be seen that, in general, the ring vessels of the spring wood together with the rays, resist disintegration but all the tissues in between, i.e. the vessels, fibres and wood-parenchyma, sooner or later disintegrate. As the pore ring is only approximately 50–100 μ deep, and the summer wood, occupying the space between two successive rings may be up to 400 μ deep, the extent of this disintegration is considerable.

It is interesting to compare the above semi-diagrammatic figure with a photomicrograph by Hubert (1931, Pl. 5, p. 78), showing a transverse section of *Ulmus americana* infected with a wood-destroying fungus (not named), contrasted with a transverse section of sound wood. Hubert's Fig. *A* does not show a very advanced state of decay but the reduction of the thickness of the fibre walls is very clearly brought out by comparison with Fig. *B*.

In the elm, the effect of the fungus in converting sound wood into diseased wood and the general progress of the decay can conveniently be described as taking place in two stages, though both these stages may be present at the same time in the same cross-section. The two stages are:

(1) *Infiltration*. This first stage of decay is the occlusion of the fibres and wood-parenchyma by infiltration products. The appearance at this stage is illustrated in Fig. 3.

The figure shows a transverse section from the diseased wood and is taken immediately above a large vessel of the ring. The infiltration may occur anywhere in the summer wood. In the wood-parenchyma it takes place not only in the summer wood but also in the vasicentric parenchyma associated with the large spring vessels. Neither the spring nor the summer vessels have been found to contain these infiltration products to the extent found in lime. In the lime, however, infiltrations of vessels were only characteristically present in the early stage of decay. Later, these products disappeared from the centre outwards and so occurred round the periphery of the cell, as a gradually decreasing band, which eventually vanished altogether. In the elm, the early stage of decay is not represented in the material available, but the presence of occasional peripheral globules in the vessels of the secondarily decayed wood, which appear to be the same substance as those found in the lime at that stage, suggests the possibility that there might have been infiltration of vessels in the elm at a stage earlier than that investigated. All the infiltration products at this stage of decay stain red with Cartwright's stain, suggesting that they are some kind of lignin complex.

Fig. 3. The first stage of decay showing infiltration of the fibres.

Longitudinal sections indicate that the fibres are completely filled with these substances. They are usually absent from the vessels; the only evidence that they might have been present is the occasional occurrence of peripheral globules.

(2) *Disintegration.* The second stage of decay is illustrated in Fig. 4, which shows a cross-section taken from the summer wood towards the end furthest from the spring wood.

The beginning of disintegration appears to be the gradual disappearance of the infiltration products. By analogy with the lime it is assumed that this takes place first in the vessels. This stage is, however, not seen in this material and the first visible sign is the disappearance of these products from the fibres. This disappearance is heralded by a tendency of the products to stain blue with Cartwright's stain. Rather later (sometimes much later, and in some of the parenchyma associated with the spring wood, not at all), the products disappear from the wood-parenchyma. The contents disappear first from the centre leaving a progressively decreasing mass of products round the periphery of the cell (see Fig. 4). This disappearance of contents does not happen in all the fibres simultaneously; some remain filled while others have disintegrated completely. While the contents remain, the wall of the cell containing them always seems quite sound and gives a red colour with the stain. As soon as the products have disappeared, the wall starts to disintegrate. Whatever the element, disintegration follows the same course and is exactly similar to the state of affairs obtaining in the lime. Walls which previously stained uniformly red, now show blue patches in the sides of the wall; these patches increase in size till the whole of the side of the wall is blue but the corners remain red considerably longer. Soon after the wall has become blue it rapidly becomes thinner till only the middle lamella is left. The middle lamellae often remain attached to each other, by the still lignified corners, for some time, but eventually the middle lamella disappears, leaving a space in the tissues. It is not uncommon for some walls of a cell to break down completely while the other walls remain apparently sound.

It has been suggested that the vessels probably became infiltrated at an earlier stage than any seen in the present material. It would therefore follow that while the fibres and the wood-parenchyma have been undergoing the changes described above, the vessels might be expected to have reached a stage of advanced disintegration. This is only partly true for, though the vessels presumably become filled with decomposition products earlier than do the fibres, they disintegrate more slowly and so their walls remain comparatively sound while the walls of the fibres have reached a stage of complete breakdown. The walls of the vessels have shown an increasing tendency to react negatively to the red stain and become blue; they have also

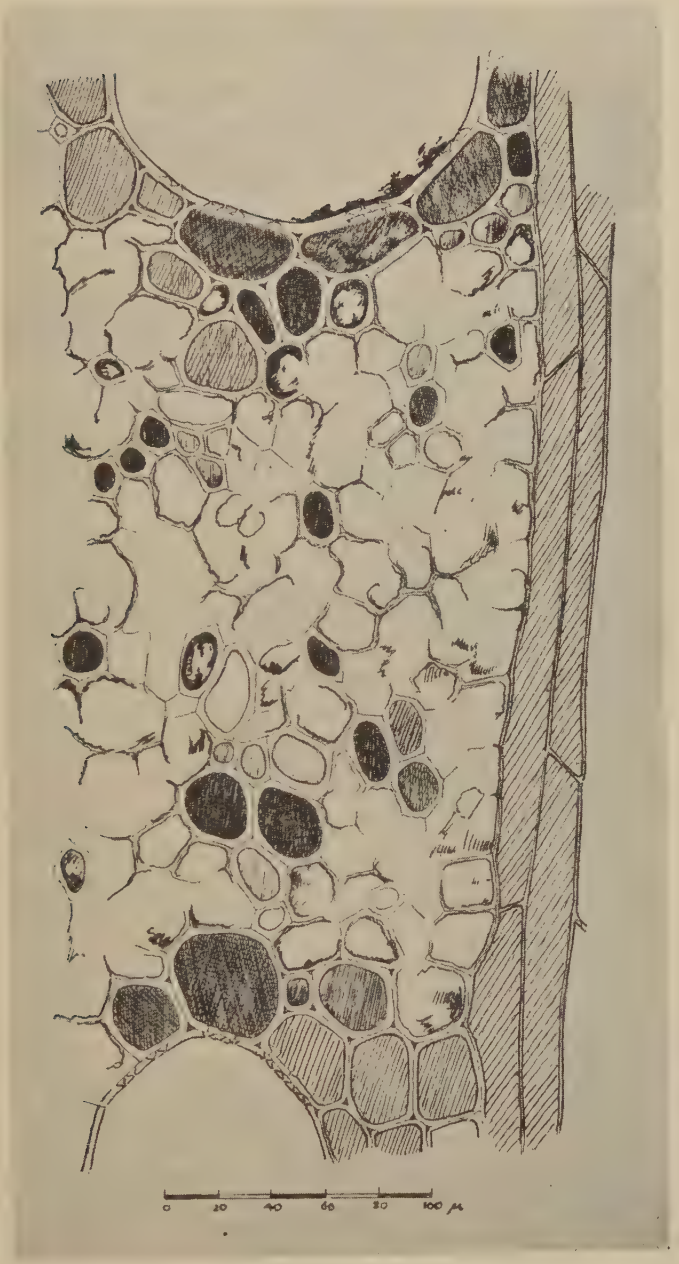

Fig. 4. The second stage of decay showing disintegration of the fibres.

become markedly thinner, but they undoubtedly resist disintegration to a greater extent than either the fibres or the wood-parenchyma.

The ray walls have, during this time, shown signs of delignification and they have become extremely thin. It seems, however, that they never become completely disintegrated.

The final stage of decay is merely a continuation of the disintegration described above. It is shown in Fig. 5 in connexion with distribution of hyphae. The disintegration leads eventually to an almost complete disappearance of the fibres and wood-parenchyma as well as considerable breakdown of the vessels of the summer wood.

Throughout all this, the large vessels of the spring wood remain apparently unaffected. The walls still stain red and appear to be quite sound. The wood-parenchyma of this region, although definitely infiltrated, also resists disintegration to a marked degree. As stated, the rays never disintegrate so that there remains in the elm, as in the lime, a skeleton formed of spring vessels and rays which persists almost indefinitely and causes the wood to retain a structural outline even in the most advanced stage of decay.

The two stages of decay here referred to as "infiltration" and "disintegration" respectively, correspond almost entirely with the stages commonly referred to as "primary" and "secondary" decay.

The stages of decay described above correspond very closely with those described by Fisher (1934, pp. 109–10) in connexion with a disease of plum trees caused by *Fomes pomaceus*.

The black line. This is very broad in the diseased timber of elm, being usually about 1 mm. in width. Though invariably present round the outer margin of the diseased wood, black lines are less frequent in the diseased wood itself than they were in the lime. The inner half of the line is densely black, the cells of the wood elements being completely filled with a black amorphous mass in which details are not observable. The line finishes abruptly and the inner margin is very sharply defined. The outer half of the line is brownish and, from this edge, brownish hyphae about 4 μ in diameter grow out into the vessels and rays. They extend for a distance of about 100 μ in the former and about 250 μ in the latter. In all essential details, the black line of the elm is similar to that of lime as shown in the previous paper (1936, pp. 151–2, Figs. 6, 7).

(ii) *The distribution of the hyphae in the tissues.*

No hyphae are found outside the black line. Inside the line, hyphae are abundant throughout the diseased wood, sometimes so abundant that they almost fill the cells. They are about 1 μ in diameter; the only hyphae larger than this are those already mentioned in relation to the black line and these are never found in the diseased wood. The hyphae occur in all the wood elements, large and small vessels, fibres,

rays and wood-parenchyma, though in those elements which contain infiltration products it is generally quite impossible to distinguish

Fig. 5. Showing the distribution of the fungal hyphae in thoroughly decayed wood.

them. The relative abundance and distribution of the hyphae as seen in a transverse section of a piece of timber in the final stage of disintegration is shown in Fig. 5.

Hyphal penetration appeared to be entirely by means of pits. Both small and large hyphae effected penetration exactly as in the lime.

VI. Conclusions

This elm disease is interesting because it provides another clear example of timber decay caused by *Ustulina* in temperate climates and justifies an investigation of the parasitism of this fungus. A marked feature of this work is the similarity which exists between this disease of elm and the disease of lime previously described in this series. In both there is a striking similarity between the macroscopic aspects of the diseased timber, also, in both there is a consistency in the types of wood elements which disintegrate and those which resist disintegration; the final result of the decay is the same in all essential details. The distribution and method of penetration of the hyphae and the characteristics of the black line are identical in each of the trees studied.

One point of difference is that in the elm there is no evidence of the primary stage of decay as shown in the discoloured wood of the lime. This is intimately associated with the significance of the black line in restricting the extent of the decay, but further explanation is deferred pending investigation on this point.

The chemical analysis of the lime timber by Campbell and Wiertelak (1935) has thrown valuable light on the effect of the fungus in the disintegration of that timber, and their findings might be assumed to apply equally well to elm. They state that, at the most advanced stage of the decay, approximately one third of the cellulose and one quarter of the lignin were decomposed and suggest that the fungus derives the greater part of its nourishment from the carbohydrates of the cell walls of the wood. In the elm the disappearance of the lignin has been stressed because that is the more easily demonstrated by microchemical methods. It is, however, obvious that the cellulose is depleted by disintegration and Campbell and Wiertelak's work is a quantitative confirmation of a qualitative observation. Their analysis also makes it fairly certain that the by-products of primary decay (i.e. infiltration products), are ultimately decomposed and though the microtechnical methods have consistently indicated that this is true, it is gratifying to have it confirmed.

As a result of the observational and experimental work put forward in this paper, there is justification for stating that *Ustulina vulgaris* causes a white rot of elm. It is not at present possible to state the degree to which the disease is prevalent or serious on this tree as this can be determined only by further observation over a considerable period.

VII. Summary

1. A diseased elm was investigated with the object of showing that *Ustulina* was responsible for the disease, and of continuing an attempt to establish the status of this fungus as a pathogen of timber trees in temperate regions.

2. The causal organism was isolated and found to be solely *Ustulina*. This was confirmed by reinfection and subsequent reisolation.

3. The stem and roots of the tree were sectioned and examined to determine the nature and extent of the disease.

4. Microscopic examination of the wood showed that the type of disintegration of the wood elements compared closely with that of the lime and that the final result of decay was almost identical in both.

5. The distribution of the mycelium and hyphal penetration is briefly commented on.

6. This elm disease is compared with the lime disease and it is concluded that *Ustulina vulgaris* is capable of causing a white rot of elm.

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A NEW SCLEROTIGENIC SPECIES OF *PENICILLIUM*: *P. PULVILLORUM*

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(With Plate IV)

During an investigation of the soil flora responsible for the degradation of sterols, a species of *Penicillium* was encountered which was characterized by the production of a great abundance of sclerotium-like masses on all ordinary culture media. Although cultures have been maintained upon various media with frequent subcultures during eighteen months, these pseudoparenchymatous masses have, throughout this time, remained soft and quite unlike the hard typical structures of, for example, *P. Thomii* Maire, *P. Raistrickii* G. Smith (1933), or *P. pusillum* G. Smith (1939). They have, moreover, shown no evidence of becoming ascogenous, although their production has continued through successive subcultures apparently undiminished.

The soil sample from which the mould was isolated was taken from an area in Middlesex which had recently been converted for building purposes; it was quite unworked, and consisted of a very acid clay. After the lapse of a year, during which time the land had been treated with dressings of lime and various synthetic fertilizers, attempts to isolate the mould were, without exception, unsuccessful. The mould has not been encountered in any other soils examined, although these have included samples of widely varying types taken not only from the neighbouring district, but also from various other parts of the country.

The penicilli are of more or less divaricate type, and the mould is probably to be included among the other soil Penicillia of Thom's "Lanata-Divaricata" (1930). The "soft sclerotia" constitute such an outstanding feature of this mould, whilst the other morphological and cultural characters are together so divergent from those of the known sclerotigenic forms, that the proposal of a new species, *P. pulvillorum*, would seem to be justified.

Diagnosis

Penicillium pulvillorum sp.nov.

Coloniis in agaro Czapekii late crescentibus, floccosis, compactis, saepe rugosis, primo virideolis, zonatis, dein brunneolis, marginibus albis deinde fulvis 3–5 mm. latis; reverso primo incolorato, subzonato et fulveolo in cultis senibus; conidiophoris ex hyphis repentibus,

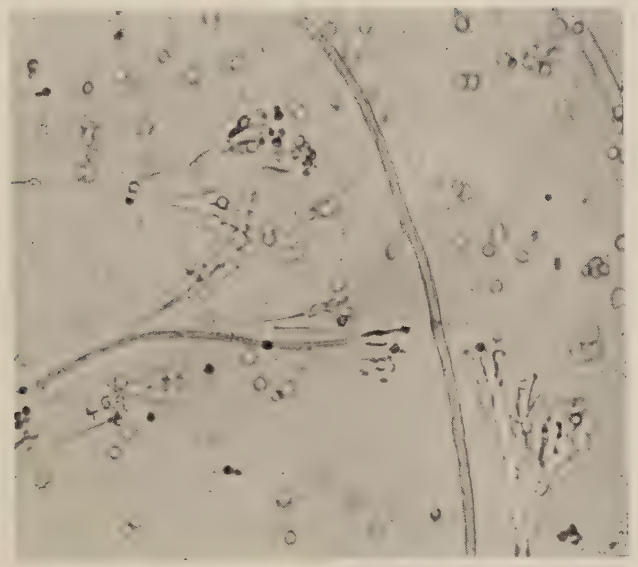

Fig. 1.

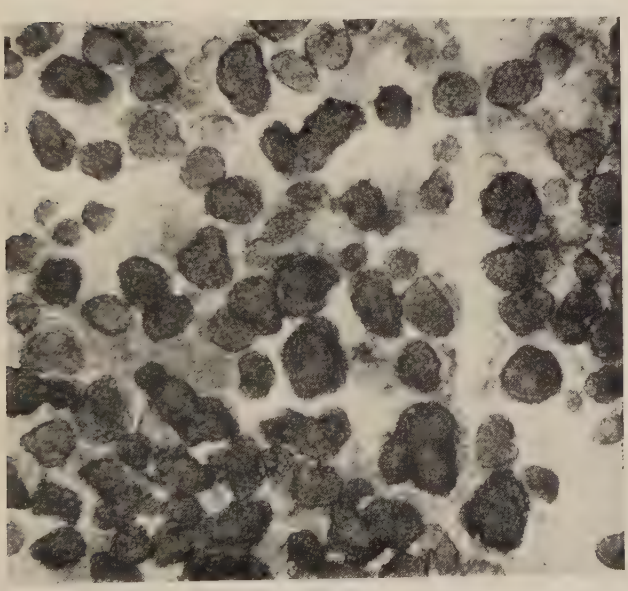

Fig. 2.

brevibus, asperulis, 1·5–3 μ crassis; penicillis plerumque divaricatis raro non ramosis, saepe cum penicillis secundariis monoverticillatis; metulis 3–3·5 × 12–25 μ; sterigmatibus acuminatis 2·5–3 × 8–10 μ; conidiis globosis, glabris, 2·5–3 μ diam.; sclerotiis abundantibus, fulveo-brunneis, mollibus, inequalibus, circiter 700 μ diam.

Habitat in terra, Londonii.

The fungus grows almost equally well on wort and Czapek agar, and the appearance of the colonies on both media is closely similar.

Colonies on Czapek agar at 24°, matted floccose, often radiately wrinkled, spreading, becoming 35–40 mm. in diameter, 0·5–1 mm. deep in 8 days; marginal zone raised, white, passing later to brownish shades, 3–5 mm. wide; conidial areas at first pale green, becoming deeper green, clearly zonate towards growing edge with zones about 2 mm. apart, gradually turning brownish from centre outwards with development of sclerotia; reverse colourless at first, then somewhat zonate in pale yellow shades, becoming deeper yellow and brownish in age; odour none; conidiophores commonly arising as short branches from trailing hyphae, 1·5–3 μ in diameter, with walls markedly roughened; penicilli occasionally as single verticils of sterigmata, usually divaricate with terminal groups of 2–3 metulae, and with secondary penicilli, mostly monoverticillate, arising from lower nodes of main axis; metulae mostly 3–3·5 μ in diameter, varying greatly in length, 12–25 μ; sterigmata 8–10 × 2·5–3 μ, sharp-pointed, with conidial chains roughly parallel or more or less divergent, becoming tangled in age; conidia 2·5–3 μ in diameter, smooth, globose; sclerotia very abundant, forming early amongst superficial growth of trailing and anastomosing hyphae, yellow-brown, irregular in shape, very variable in size, averaging 700 μ in diameter, consisting of compact hyphal masses, remaining soft; development of asci not observed.

I am much indebted to Mr G. Smith for his opinions on the diagnosis, and for the photographs taken from my slides.

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EXPLANATION OF PLATE IV

Both figures are from photographs of specimens mounted in lacto-phenol-picric acid.

Fig. 1. *P. pulvillorum.* Penicilli. × 500.

Fig. 2. *P. pulvillorum.* Sclerotial masses. × 100.

(*Accepted for publication* 22 *March* 1939)

PRELIMINARY ACCOUNT OF THE ODOUR OF WOOD-DESTROYING FUNGI IN CULTURE

By E. C. BADCOCK

(With 1 Text-figure)

Introduction

As far back as 1908 Rumbold and Mez recorded that certain Basidiomycetes, when cultured, produce characteristic odours. Bavendamm (1928) described further cultural odours of wood-destroying fungi.

Gilbert (1934) gave a useful classification of the odours of the natural fruit bodies (translated on pp. 196 and 197), and in many systematic works dealing with the fungus-flora, one finds brief descriptions of the odour of certain species, e.g. "smells of anise", "pleasant odour", "odour of new meal".

Some interesting work was done on chemotaxis by Buller (1922), using certain Basidiomycetes and a species of slug. Fabre (1900) carried out similar tests with the fungus *Hydnocystis arenaria* Tul. and a species of beetle (*Bolboceras gallicus* Muls.). These two writers showed that the sense of smell guides the animal to the concealed fungus.

Apart from these writings there appears to be no record of work done on the odours of the higher fungi.

The odours of fungi in pure culture

The odours of wood-destroying fungi, when growing in pure culture, have been studied with a view to assisting in identification. It has been found that odour may furnish a useful clue to the identity of some species. These odours may also yield useful information on the metabolism of wood-destroying fungi.

The diagnostic value of these odours is shown by the two following examples:

(1) A piece of decayed willow, without fruit-body or external mycelium, was sent into the laboratory for identification of the fungus causing the decay. Cultures were taken and a wood-destroying fungus was isolated. The culture showed no marked characteristics by which it could be recognized, nor could it be induced to fruit, but an odour resembling anisaldehyde was detected, which resembled that of the fruit body of *Trametes suaveolens*. Comparison with cultures of this fungus proved that the decay had been caused by this fungus.

(2) Several disks of Norway spruce without any external fungus, but showing a brown stain, were sent in for diagnosis. A culture of a wood destroyer with a fragrant smell was isolated from several of the disks. The odour was recognized as being the same as that produced by *Stereum sanguinolentum*. The cultures were compared and found to be identical.

A number of other fungi in which odour has assisted identification are:

Merulius himantioides, *Lenzites trabea*, *Pholiota adiposa*, *Lentinus lepideus*, *Polyporus durus*, *P. benzoinus*, *Polystictus versicolor*.

Method employed for the study of cultural odours

(1) The medium used for most of the fungi was autoclaved 2 % Kepler's malt extract and 2 % agar-agar, made up with tap water. Fungi that would not grow on this medium were cultured on 5 % Kepler's malt extract, 2 % agar-agar and 0·5 % malic acid. The volume of medium was 50 c.c., sloped in a boiling tube (diameter 4 cm.). Small tubes containing 10–15 c.c. of sloped medium are unsatisfactory for odour testing. Two cultures were made of each fungus under test.

In order to ascertain if the medium affects the odour of a fungus, cultures of several fungi possessing characteristic odours were grown on both media and also on prune juice agar. It was usually found that there was either no perceptible difference in odour or only a slight one.

(2) The plugs were not covered with rubber caps because these imparted a strong odour of rubber to the top of the tube. Rather tightly fitting plugs were used instead. These were not flamed as it was found that a flamed plug gave a strong burnt smell to the top of the tube—especially when the lower half of the plug was flamed.

(3) The cultures were incubated at 20° C. until growth began, and were then placed in the laboratory and exposed to diffuse daylight.

(4) No fungus was tested for odour until the slope was completely covered by the mycelium.

(5) The best time to test a fungus for odour is usually when it is about six weeks old—assuming that the medium has been covered in that time. The characteristic odour may sometimes, however, be detected after only two weeks' growth, a circumstance helping rapid identification. When the period differed from the standard one of six weeks this has been noted in the Table given below. Exceptionally, the odour does not develop until after six or more weeks, and with other fungi it may diminish after three weeks: normally, however, a culture tends to lose its odour after about twelve weeks. Certain fungi (e.g. *Pholiota mutabilis*) change their odour appreciably during early development. Any such changes are noted in the Table.

(6) Smoking immediately prior to testing should be avoided. Gilbert mentions that Fries had a confused sense of smell owing to his liking for snuff! Persons familiar with chemical odours were called in to give their opinion on the odour of each culture as a check. There was occasionally some diversity of opinion, especially with the more fragrant odours.

It was found that some fungi did not emit sufficient odour in the tube for one to detect, but that when a piece of mycelium, measuring approximately 2 cm. square, was extracted from the tube and smelt, the odour was often very pronounced. This is probably due to the bruising of the mycelium. It was noticed that cultures of fungi that emit odour only when their mycelium is cut or bruised, usually form a tough, skin-like mycelium, e.g. *Marasmius alliaceus*, *Polystictus versicolor* and *Trametes rubescens*.

The objection to the latter method of odour detection is that the slight smell of the medium tends to be mixed with that of the fungus. The normal age of the culture when tested was six weeks.

Constancy of odour

All the tests were repeated some months later, and the same odours noted previously were produced. There was no appreciable difference between the odours emitted by different strains of the same fungus—even when isolated from different hosts. More than one strain of the following species were tested and the odours were found to be constant:

Polyporus benzoinus (2), *P. Schweinitzii* (2), *Fomes fomentarius* (2), *F. fraxineus* (2), *F. pinicola* (2), *Pholiota squarrosa* (2), *P. mutabilis* (2), *Polystictus versicolor* (6, including an Indian one), *Stereum sanguinolentum* (9), *Lentinus lepideus* (4) and *Trametes suaveolens* (4).

The numbers in brackets show how many strains of each species were tested.

Different types of odour

Many of the odours were of the ester type and some fungi appear to contain ethereal oils. The odour of *Lenzites striata* is difficult to describe, but it was possible to reproduce it with a weak solution of iodine to which a minute trace of ether was added.

Marasmius alliaceus produces a distinct odour of garlic in culture. Twenty-five-day old cultures of this fungus, which had been grown in the light at room temperature, were tested for odour. Pieces of white mycelium were extracted from each of these cultures and were found to be inodorous, but pieces of brown mycelium emitted a strong odour of garlic. This is not so marked in older cultures, where the white mycelium has a faint odour of garlic.

Cultures of *M. alliaceus* exposed to light are white for the first three weeks, changing to mars brown and light seal brown (Ridgway)

Fig. 1. 25-day-old culture of *Marasmius alliaceus*.

around the inoculum about two days later (see Fig. 1). Old cultures never become wholly brown. *M. alliaceus* is usually found growing among leaves in woods, but Rea (1922) recorded it growing on rotten wood. It is probably of secondary importance as a wood destroyer.

The odour of hydrocyanic acid is unmistakable in certain cultures. Gilbert states that it is possible to demonstrate the presence of this acid by means of Guignard's picro-soda paper, in the fruit-bodies of eight different species of the higher fungi, including the wood-destroyers *Trametes amygdalea* and *Pleurotus porrigens*; he adds that *Hygrophorus agathosmus*, which has a cyanic odour, does not contain hydrocyanic acid, but possibly benzoic aldehyde.

Localization of odour

Occasionally one finds reference to odour in systematic mycological works such as "smell strong or none". These irregularities may be accounted for in part by some interesting statements by Gilbert: "The hymenium of *Clitocybe geotropa* emits the odour of hydrocyanic acid...." "The base of the stipe of *Russula amethystina* often emits the odour of iodine...." "The spores of *Nematoloma dispersum* emit the odour of iodine characteristic of this species."

This evidence suggests that when the characteristic odour is absent from a fruit-body it may be because the specimen is immature, over-mature and/or incomplete. Again, atmospheric conditions may have caused a temporary loss of odour. In culture, conditions are more or less uniform. With a non-fruiting culture one is relying on odour of the vegetative mycelium only, thus obviating such variables as absence or presence of basidiospores, and the substratum and age of the fungus growth are known.

So far, only *Marasmius alliaceus* has been found to have its odour localized in certain parts of the vegetative mycelium in young cultures (see p. 190).

Many species, whose natural fruit-bodies have no detectable odour, produce a distinctive scent from the mycelium in culture, e.g. certain species of *Stereum*. Gilbert states that the mycelia of some species of *Corticium* emit a pronounced alliaceous odour.

In the Table below, the odours of the cultures are noted. Sometimes the odour could not be compared with that of any definite substance; therefore, rather general descriptions such as "fragrant" appear.

The expression "may be detected when mycelium is extracted from tube" relates to the second method mentioned on p. 190. One column of the Table contains notes on the odour of the natural fruit-body mentioned in systematic works. "None recorded" shows that it was not possible to trace any reference to odour in the fruit-body. The initials "C.R." and "R." show that the note was obtained

from the works of C. Rea (1922) and Ramsbottom (1923) respectively. All the fungi listed are wood destroyers, including many of economic importance.

Table I

Fungus	Odour of culture	Odour of natural fruit-body
Coprinus micaceus (Bull.) Fr.	None*	None recorded
Daedalea quercina (Linn.) Fr.	Apples. 3 weeks	None recorded
Fomes fomentarius (Linn.) Fr.	Oily, almost of tallow—may be detected when mycelium is extracted from tube	None recorded
F. fraxineus (Bull.) Fr.	Faintly of sardines when mycelium is extracted from tube	None recorded
F. Laricis (Jacq.) Murr.	Faintly fragrant	"Farinaceous." Shope
F. lignosus Klotzsch	None	None recorded
F. noxius Corner	None	None recorded
F. pinicola (Sw.) Cke.	Fish and tallow—may be detected when mycelium is extracted from tube	None recorded
F. scutellatus Schwein.	Hydrocyanic acid or cherry laurel	None recorded
Ganoderma applanatum (Pers.) Pat.	Faintly of tallow when mycelium is extracted from culture	None recorded
G. oregonense Murr.	Slightly fragrant when mycelium is extracted from tube	None recorded
G. resinaceum Boud.	None	None recorded
Lentinus cochleatus (Pers.) Fr.	Faintly of 5 % anisaldehyde in proof spirit. 7 weeks	"V. pleasant of anise or tonquin bean." C.R.
L. lepideus Fr.	10 % anisaldehyde in proof spirit	"Pleasant." C.R.
Lenzites abietina Bull.	None	None recorded
L. betulina (Linn.) Fr.	Fish combined with tallow—may be detected when mycelium is extracted from tube	None recorded
L. flaccida Fr.	Tallow—may be detected when mycelium is extracted from tube	None recorded
L. repanda (Mont.) Fr.	None	None recorded
L. sepiaria (Wulf.) Fr.	Slightly spicy	None recorded
L. striata Schwartz	Iodine, with faint trace of ether, rather unpleasant, "bitter"	None recorded
L. trabea Pers.	Rubber and iodine, "bitter"	None recorded
L. tricolor (Bull.) Fr.	Slightly of pepper. 8 weeks	None recorded
Marasmius alliaceus (Jacq.) Fr.	Garlic—may be detected when mycelium is extracted from tube. Odour stronger from brown mycelium	
Merulius confluens Schw.	Moderately fragrant	None recorded
M. himantioides Fr.	Iodine and rubber, rather unpleasant, "bitter". 7 weeks	None recorded
M. lacrymans (Wulf.) Fr.	Very slight fungus odour	"Often strong somewhat of fish." R.
M. rufus (Pers.) Fr.	Faintly of mushrooms	None recorded
M. tremellosus (Schrad.) Fr.	Burnt toffee. 3 weeks	None recorded
Paxillus atrotomentosus (Batsch.) Fr.†	Unbleached calico. 8 weeks	None recorded
P. panuoides Fr.†	Unbleached calico + slight fragrance. 8 weeks	"Often very fragrant." C.R.

* When a fruit-body is deliquescing there is a strong mushroom odour.
† Grown on 5 % malt, 2 % agar, 0·5 % malic acid.

Table I (*cont.*)

Fungus	Odour of culture	Odour of natural fruit-body
Pholiota adiposa Fr.	Earthy	None recorded
P. lucifera (Lasch.) Fr.	Earthy	None recorded
P. mutabilis (Schaeff.) Fr.	Earthy at 2 weeks, fragrant at 6 weeks	"Agreeable odour though feeble." Quélet
P. spectabilis Fr.	Sickly sweet at 3 weeks like the blooms of meadow sweet (*Spiraea ulmaria*)	"Pleasant." C.R.
P. squarrosa (Müll.) Fr.	Strong, earthy. 4 weeks	"Unpleasant, like rotting wood, sometimes none." C.R.
Pleurotus euosmus (Berk.) Cke.	Fragrant	"Strong sweet smell like that of tarragon." R.
P. lignatilis Fr.	New meal—may be detected when mycelium is extracted from tube	"Strong, of new meal." C.R.
P. ostreatus (Jacq.) Fr.	Slightly fragrant 6 weeks, mushrooms 10 weeks	"Pleasant." C.R.
P. sapidus (Schulz.)	Fragrant. The mycelium in culture has the strong odour of the natural fruit body	"Pleasant." C.R.
P. ulmarius Bull.	None 6 weeks, slightly fragrant 9 weeks	"Pleasant or somewhat acid." C.R.
Polyporus adustus Fr.	Faintly fragrant (terpenoid)	"None, rarely fragrant." C.R.
P. anceps Pk.	None	None recorded
P. benzoinus (Wahlenb.) Fr.	Equal parts benzaldehyde and anisaldehyde	"Very pleasant, aromatic." C.R.
P. betulinus (Bull.) Fr.	Apples. 8 weeks	None recorded
P. croceus (Pers.) Fr.	Narcissus. 6 weeks—none at 7 weeks	None recorded
P. durus Jungh.	Pleasant, fruity, resembling quince	None recorded
P. frondosus Fr.	Faintly of hydrocyanic acid or cherry laurel	"New meal." C.R.
P. fumosus (Pers.) Fr.	None	"Strong, or none." C.R.
P. graveolens Schwein.	Unpleasant at 6 weeks, almost odourless at 7 weeks	None recorded
P. mollis (Pers.) Fr.	None	None recorded
P. mikadoi Lloyd	None	None recorded
P. obducens (Pers.) Fr.	Hydrocyanic acid or cherry laurel	None recorded
P. obtusus Berk.	Moderately fragrant. Jasmine	None recorded
P. picipes Fr.	Slightly fragrant—almost benzoin resinoid	None recorded
P. rutilans (Pers.) Fr.	Slightly fragrant	"Anise." R.
P. Schweinitzii Fr.*	Pleasant almost anise, when mycelium is extracted from tube	None recorded
P. squamosus (Huds.) Fr.	None	"Strong." C.R.
P. sulphureus (Bull.) Fr.	None	None recorded
Polystictus tabacinus Mont.	None	None recorded
P. versicolor (Linn.) Fr.	Fish and tallow—may be detected when mycelium is extracted from tube	None recorded
Poria Vaillantii (D.C.) Fr.	Faintly of mushrooms	None recorded
P. xantha Lind	Resembling limonene, or almost lemon	None recorded
Stereum frustulosum Fr.	Fruity. Rotting apples, but rather more spicy	None recorded
S. hirsutum Fr.	Faintly fragrant. 10 weeks	None recorded

* Grown on 5 % malt, 2 % agar, 0·5 % malic acid.

Table I (*cont.*)

Fungus	Odour of culture	Odour of natural fruit-body
Stereum illudens Berk.	Sweet, like over-ripe peeled banana at 4 weeks, faint at 6 weeks	None recorded
S. lobatum Fr.	Very faintly sweet	None recorded
S. Murrayi (B. & C.) Fr.	Vanilla at 5 weeks, faint at 6 weeks	None recorded
S. purpureum Fr.	Moderately fragrant at 6 weeks, sheep or wet wool (higher fatty acid) 10 weeks	None recorded
S. rugosum (Pers.) Fr.	Fruity, over-ripe peeled banana. 8 weeks	None recorded
S. sanguinolentum (A. & S.) Fr.	Fragrant at 6 weeks, faint at 10 weeks	None recorded
S. spadiceum Fr.	Very faintly fragrant at 6 weeks, none at 10 weeks	None recorded
Trametes malicola B. & C.	Faintly fragrant	None recorded
T. odorata Wulf.	Fruity	"Strong, pleasant, like hay or spicy." C.R.
T. Pini (Brot.) Fr.	None	"Slightly pleasant." C.R.
T. rubescens (A. & S.) Fr.	Faintly of tallow—may be detected when mycelium is extracted from tube	None recorded
T. suaveolens (Linn.) Fr.	Strong, almost anisaldehyde	"Strong of anise." C.R.
T. tenuis Karst.	None	None recorded
Ustulina vulgare Fr.	None	None recorded
Xylaria Hypoxylon (L.) Grev.	Nitrous odour when mycelium is extracted from tube	None recorded
X. polymorpha Grev.	None	None recorded

As yet an insufficient number of wood-destroying species have been tested to enable definite conclusions to be drawn. It is of interest, however, that there is sometimes a striking similarity of odour between certain species of the same genus, e.g. *Lenzites striata* and *L. trabea*; *Paxillus atrotomentosus* and *P. panuoides*; *Pholiota adiposa*, *P. lucifera*, *P. mutabilis* and *P. squarrosa*, and between certain species of *Stereum*. Systematists have already noticed that, with the natural fruit-bodies, there is often a likeness between the scents of the species within certain genera, e.g. in *Russula*, *Collybia*, *Marasmius*, *Tricholoma* and *Mycena*. The following remarks by Hampton (1925), referring to flower odours, seem to apply also to those of the higher fungi: "On the whole the variety of scent within a genus is more striking than its similarity, although we can usually detect a family likeness behind the difference."

This preliminary work on odours produced in culture by wood-destroying fungi indicates that this character should take its place amongst others, such as mat texture and colour, as a useful aid in identification, and also should, if studied from a chemical aspect, afford further light on their metabolism.

List of the odours of the natural fruit-bodies of the higher fungi. Compiled by E. J. Gilbert (1934)

A. *Fungi without odour.*

Fungi without odour, scarcely perceptible, or very feeble.

B. *Fungi with special odours.*

Fungi with decided odours.

(1) *Tones of agreeable odours.*

Fungus odour.

Mealy odour.

Fruity odour.

Jasmine odour.

Orange blossom and Neroli odour.

Linalic odour.

Rose-geranium odour.

(*a*) Rose.
(*b*) Geranium.

Honey odour.

(*a*) Honey.
(*b*) Beeswax.

Coumaric odour.

Balsamic odour.

(*a*) Vanillin.
(*b*) Terebinth.

Odour of leaves.

Salicylic odour.

(*a*) With scent of methyl salicylate (wintergreen).
(*b*) With scent of salicylic aldehyde.

Anise odour.

Cyanic odour.

(*a*) Plain.
(*b*) Benzoic.

Violet-iris odour.

Musk odour.

(*a*) Of animal origin.
(*b*) Of vegetable origin.

(2) *Tones of disagreeable odours.*
Oily (tallow) odour.
Butyric odour.
Nauseous odour.
Radish odour.
Onion (alliaceous) odour.
Chlorine odour.
Marine odour.
Ammoniacal odour.
Foetid odour.

Summary

The diagnostic value of the odours of cultures of wood-destroying fungi is discussed. Two methods are described for the detection of these odours.

The odour remained constant when the tests were duplicated and, moreover, there was no variation between different strains of the same species—even when isolated from different hosts. (For many species more than one strain was not available.)

Certain species, whose natural fruit bodies are inodorous, produce a distinctive scent from the mycelium in non-fruiting cultures.

Young cultures of *Marasmius alliaceus* have the strong garlic odour localized in the brown mycelium, the white mycelium being inodorous.

No two species have been found with exactly the same odour. Certain related species possess similar ones.

A table is included, describing the odour of cultures (if present) of eighty different species; and, for comparison, that of the natural fruit body of these species as recorded in systematic works.

Acknowledgements

I am indebted to W. A. Robertson, Esq., Director of Forest Products Research, for permission to publish this paper; to Mr K. St. G. Cartwright and Dr T. H. Duvrans for helpful advice, and to many others who have given their opinion on the odours.

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OLPIDIUM BRASSICAE (WOR.) DANG. AND ITS CONNECTION WITH *ASTEROCYSTIS RADICIS* DE WILDEMAN

By KATHLEEN SAMPSON

(With Plate V and 1 Text-figure)

Introduction

Olpidium Brassicae (Wor.) Dang. was first recorded in the roots of cabbage and figured by Woronin (1878). The resting spores are described as colourless or pale yellow with a thick membrane and more or less stellate. The contents are granular, with one large or several small oil drops (Pl. V, fig. 1). De Wildeman (1893) figured cysts of *O. Brassicae*, together with other cysts which he regarded as distinct and named *Asterocystis radicis*. These were stellate, with a large central refractive globule, and they could not be plasmolysed with glycerine, whereas those of *Olpidium Brassicae* were easily plasmolysed. His figures of the new species showed a star within a circle or ellipse (Pl. V, fig. 4). In the same paper De Wildeman figured oblong zoosporangia with one or more exit-tubes, and to these he gave the name *O. Borzii* n.sp., a name changed to *O. radicicolum* in a later paper (1896).

Marchal (1900), working with flax, found stellate cysts (Pl. V, fig. 5) identified as *Asterocystis radicis*, associated with zoosporangia, which appeared to discharge their zoospores through a small lateral opening, and not through a definite exit-tube.

Subsequently, stellate cysts and zoosporangia possessing exit-tubes of variable length have been found in a number of different plants. They have usually been recorded as *Asterocystis radicis* (Fron & Gaillat, 1925; Guyot, 1927; Vanterpool, 1930), more rarely as *Olpidium Brassicae* (Bensaude, 1923) or *O. radicicolum* (Bartlett, 1928), but most authors comment on the difficulty of distinguishing these species. This is hardly surprising, since the cysts of the first two species are described as stellate, and little additional information is given in the original papers. The distinction rests almost entirely on De Wildeman's drawings (1893), for he is one of the few workers who claims to have seen all three species. Němec (1912) also keeps them distinct. Both Guyot (1927) and Karling (1937) suggest that *Asterocystis radicis* and *Olpidium Brassicae* probably refer to the same organism, while Bartlett (1928) gives *Asterocystis radicis* and *Olpidium radicicolum* as synonyms.

In 1937, the opportunity arose of observing an *Olpidium* with stellate cysts in members of the Cruciferae and Gramineae, two of the families which most frequently serve as hosts for the above species. The *Olpidium* was first discovered in the roots of species of *Agrostis* growing in rather waterlogged soil. Seeds of cauliflower were sown in the same pots, and in two to three weeks their roots were abundantly parasitized by what appeared to be the same species, though not necessarily the same strain, of *Olpidium*. Observations were made on living roots and on material fixed and stained. For further comparison fresh material of *O. Brassicae* on cabbage was obtained by the kindness of Mr G. Samuel. To Mr Bartlett I am indebted for swedes bearing the so-called "hybridization nodules" and containing in their finer rootlets zoosporangia and cysts of an *Olpidium* which he identified as *O. radicicolum* De Wildeman.

The wide range in size and shape of the zoosporangia in the four collections of material examined, together with observations on the structure of the wall of the cyst, have convinced me that the parasite is the same on the four hosts. A careful comparison of this material with published records leads to the conclusion that *Olpidium Brassicae* (Wor.) Dang., *Asterocystis radicis* De Wildeman, and *Olpidium radicicolum* De Wildeman are synonyms, the first name having priority.

Examination of material from roots of *Agrostis*, cauliflower, cabbage and swede

(1) *Zoosporangia*

In all roots examined, the zoosporangia were extremely variable in size and shape, ranging from spherical units 12 μ in diameter, and opening by a single exit-tube, to elongated individuals 130 μ in length which may possess as many as four exit-tubes. Bartlett found sporangia as long as 220 μ. The diameter of each thallus is related to that of the host cell, which is not hypertrophied. Zoosporangia usually fill the short diameter of the cell, but sometimes exceptionally small zoosporangia are seen, and these may discharge zoospores into the cell itself. The same cell may contain small and large zoosporangia, and they are not uncommonly mixed with cysts (Text-figs. 1–18). In Woronin's figures of *Olpidium Brassicae*, spherical zoosporangia only are shown, and it was this which led De Wildeman to establish his species *O. radicicolum*. Possibly the fact that Woronin used transverse sections of the root may account for the absence in his drawings of long zoosporangia. Van der Meer (1926) and Bartlett (1928) also found spherical and elongated sporangia in the same root.

Confusion has arisen in regard to the length of exit-tubes, perhaps because the figure of *O. Brassicae* that found its way into most text-books showed only zoosporangia with long necks. In one of Woronin's

figures, however, both long and short exit-tubes are shown (Pl. V, fig. 1), and Woronin knew that the length of the tube depended upon the distance between the parasite and the outer wall of the root. This is quite clear in any material I have examined. It is not possible to observe an exit-tube on every mature thallus, possibly because of the position of the thallus in the cell, and this may, perhaps, explain the absence of exit-tubes noted by Marchal (1900) in his first record of the zoosporangia of *Asterocystis radicis*.

The gradation between the most extreme types of sporangia in all the material examined made it impossible to doubt that they belonged to one organism.

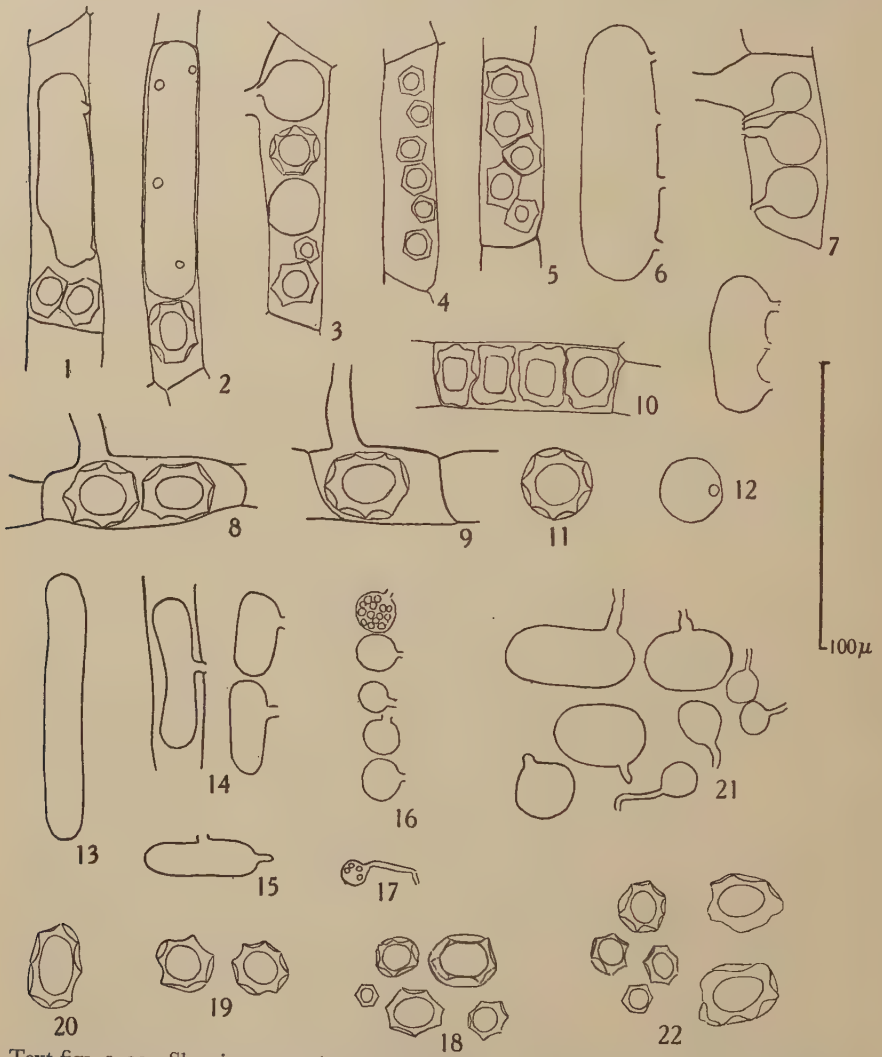
Zoospores escaped readily when suitable roots were mounted in fresh water. They are approximately 3 μ in diameter and possess a single long cilium which trails behind when swimming. The cilia are well shown in slides prepared with Noland's stain (Pl. V, fig. 8)(Noland, 1928).

(2) *Resting sporangia* (*cysts*)

The resting sporangia vary widely in size, ranging from 8 to 30 μ in diameter (Text-figs. 1–22). Fifty cysts taken at random from a single root of cabbage varied from 13 to 30 μ in diameter, fifty taken from a root of *Agrostis* gave a range of 8–26 μ, the modal length for both samples being 17 μ. De Wildeman gave 18–33 μ as the size of cysts of *Asterocystis radicis*, and Bartlett states that in his material they averaged 20–25 μ, but some reached 30 μ. Woronin did not provide measurements of *Olpidium Brassicae*, but it may be deduced from his figures that the cysts are 13–20 μ in diameter, and De Wildeman gave 7–10 μ as the size of cysts in this species. The cysts, like the zoosporangia, occur chiefly in the epidermal cells, only rarely in subepidermal tissue or in root hairs. They are solitary or in groups of two to six or more.

Diagnosis rests chiefly on the wall, the detailed structure of which has never been described. As in other species of *Olpidium* (Kusano, 1912, 1928–30; Sampson, 1932), the wall of the cyst is made up of three layers, a thin smooth hyaline endospore and a more strongly developed exospore with a space between. In the fungus now described the exospore is wrinkled in such a way as to form relatively high anastomosing ridges, which appear in optical section as the points of a star (Pl. V, figs. 7, 13, 15). It is usually impossible, as one realizes when trying to photograph the cysts, to get a sharp outline of several ridges in any one focal plane. When using a camera lucida a clear outline is obtained by slight changes of focus, and this gives the well-known stellate shape recognized at once as *Asterocystis radicis* (Text-figs. 4, 5, 8–11). The central circle or ellipse (= the refractive globule of De Wildeman?) represents the protoplast surrounded by the endospore, and the outer circle or ellipse in which the star appears to be enclosed is produced by the furrows.

Another way to sketch the cyst is to trace the ridges both on the surface and in profile in the hope (not always realized !) of giving the impression of a solid object. Cysts from *Agrostis* and cauliflower,



Text-figs. 1–22. Showing range in size and shape of zoosporangia and cysts of *Olpidium Brassicae* (Wor.) Dang. Figs. 1–12 from *Agrostis*; Figs. 13–18 from cauliflower; Figs. 19, 20 from cabbage; Figs. 21, 22 from swede bearing "hybridization nodules". ×370.

mounted in glycerine and drawn in this way (Pl. V, figs. 10, 11), are not altogether unlike some of De Wildeman's figures of *Olpidium Brassicae* (Pl. V, fig. 3).

Few authors have tried to show the sculpturing of the outer wall in surface view. Bensaude (1923) illustrates a cyst (tentatively identified as *O. Brassicae*) dissected from the root and drawn in perspective. A somewhat similar type of drawing is shown in Pl. V, fig. 14 of this paper.

Pl. V, figs. 12, 13, drawn under a 1/12th objective, using a camera lucida, show the ridges of the same cyst (*a*) in surface view, (*b*) in optical section. Both drawings are diagrammatic, in that images at different foci have been superimposed to give a continuous outline in one plane.

These familiar difficulties of portrayal have been mentioned only because I believe they have some bearing on the confusion which has surrounded the cysts of *O. Brassicae*. Few would doubt that the different cysts shown in Text-figs. 1–22 belong to the same organism, but they might be less ready to accept as one species figs. 7, 9–15 in Pl. V, yet their apparent differences depend only on the mounting medium, magnification and method of drawing.

In view of the scanty information supplied in Woronin's original description a fuller diagnosis is given.

Olpidium Brassicae (*Wor.*) *Dang.*

Synonyms: *Chytridium Brassicae* Wor.
Asterocystis radicis De Wildeman
Olpidium Borzii De Wildeman
O. radicicolum De Wildeman
Olpidiaster radicis (De Wildeman) Pascher.*

Zoosporangia solitary or aggregated in the host cell, thin-walled, spherical to elongate, the former 12–20 μ in diameter, the latter 20–45 × 25–220 μ, opening by one to four exit-tubes which vary in length according to the distance from the surface of the host.

Zoospores about 3 μ in diameter with a single cilium up to 17 μ in length.

Resting sporangia usually spherical, 8–25 μ in diameter (larger ones may be oval and up to 30 μ in length). Most of the cysts measure 17 μ. The exospore, which is coarsely and rather deeply wrinkled with ridges up to 3·5 μ in height, shows a stellate form in optical section, with six to nine points to the star. The endospore is thin and smooth, not united to the exospore. The cysts are probably binucleate (Němec, 1922). Their germination has not been observed.

Habitat. Roots of phanerogams, including the genera *Brassica*, *Capsella*, *Thlaspi*, *Linum*, *Plantago*, *Veronica*, *Limosella*, *Solanum*, *Avena*, *Triticum*, *Poa*, *Agrostis*, *Festuca*, *Lolium*. Associated with wet conditions.

* See Karling (1937) for a discussion of this binomial.

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EXPLANATION OF PLATE V

The writer is indebted to Dr J. H. Western for the photographs.

Figs. 1, 2. *Olpidium Brassicae* (Wor.) Dang., zoosporangia and cysts after Woronin (1878).

Fig. 3. *Olpidium Brassicae* (Wor.) Dang., cysts (no. 22 was in glycerine) after De Wildeman (1893).

Fig. 4. Zoosporangia (*Olpidium Borzii*) and cysts (*Asterocystis radicis*) after De Wildeman (1893).

Fig. 5. Cysts from flax, identified as *Asterocystis radicis* (De Wildeman), after Marchal (1900).

Fig. 6. Cysts and zoosporangia from swede, identified as *Olpidium radicicolum* (De Wildeman) after Bartlett (1928).

Figs. 7–15. *Olpidium Brassicae* (Wor.) Dang.

Fig. 7. Cyst in root of *Agrostis*, fixed Navashin's fluid and stained Haidenhain's Haematoxylin, photographed under 1/12th objective, oc. 12×.

Fig. 8. Zoospores stained Noland's fluid (Noland, 1928), photographed under 1/6th objective, oc. 12×.

Fig. 9. Relatively young cysts from cabbage, stained lacto-phenol cotton blue, drawn in optical secton under 1/6th objective, oc. 15×. ×590.

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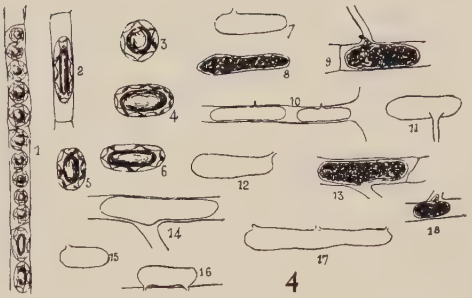
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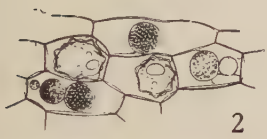
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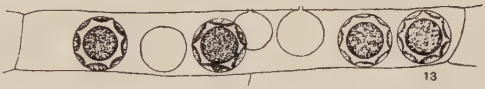
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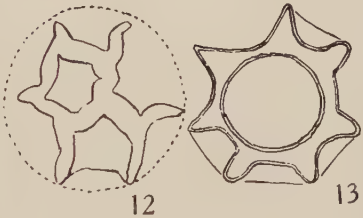
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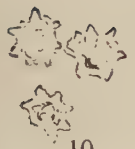
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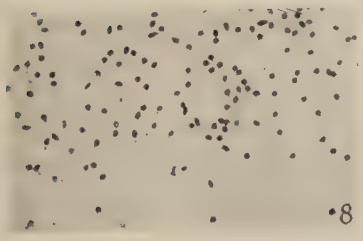
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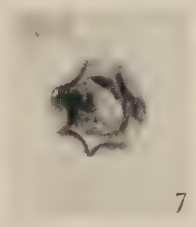
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Figs. 10 and 11. Cysts in pure glycerine, drawn as solid objects under 1/6th objective, oc. 15. × 590.
Fig. 10. From *Agrostis*.
Fig. 11. From cabbage.
Figs. 12–15. Cysts from *Agrostis*, fixed Navashin's fluid and stained Haidenhain's Haematoxylon, drawn under 1/12th objective, oc. 15. × 1720.
Fig. 12. Surface view.
Fig. 13. Optical section.
Fig. 14. Ridges in surface view.
Fig. 15. Ridges shown both in surface view and in profile.
The camera lucida has been used for all drawings with change of focus.

(*Accepted for publication* 1 *May* 1939)

THE IDENTITY AND SYSTEMATIC POSITION OF *CAMAROSPORIUM ABIETIS* WILSON & ANDERSON

By MALCOLM WILSON

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When *Camarosporium Abietis* was described as a new species by Wilson & Anderson (1924) it was not known that a similar fungus had been recorded in America. *Steganosporium cenangioides* had already been described by Ellis and Rothrock (1885) on *Abies balsamea*, and by the kindness of Dr C. L. Shear a specimen of this fungus, collected by Dearness in Ontario (*Fungi Columb.* No. 4783), has been sent for examination.

In the American material the pycnidia are generally smaller, but in other respects the fungus agrees closely with that collected in Scotland on *Abies Lowiana* and there appears to be no doubt that the two collections belong to the same species. Dr Shear also agrees with this conclusion.

Meanwhile Jørstad had discovered the same fungus in Norway in the vicinity of Bergen in 1925 on *A. nobilis* and *A. balsamea* and near Trondhjem in 1926 on *A. pectinata* and recorded it as *Steganosporium cenangioides* (Jørstad, 1925 and *in litt.*). Dr Jørstad informs me that he has no doubt as to the identity of the Norwegian and Scottish fungi and, as a result of the examination of the specimens which he was good enough to send me, I am of the same opinion.

Petrak (1927) gave a very full description of *S. cenangioides* from specimens collected by Dearness (Fungi Columb. No. 4783) and this account agrees very closely with that of *Camarosporium Abietis*. He points out that on account of its structure the fungus cannot be placed in *Steganosporium* and transfers it to *Myxocyclus* Riess, as *M. cenangioides* (Ell. & Roth.) Pet., referring to its resemblance to *M. polycystis* (B. & Br.) v. Höhn.

Grove (1937) records the fungus from several localities in Britain and places it in the genus *Camerographium* Bubák (Bubák, 1916) as *C. Abietis* Grove; he gives no reference to *Steganosporium cenangioides* Ell. & Roth.

Grove has very considerably emended the genus *Camerographium* Bubák and has made the limits so elastic that many of the pycnidial fungi with muricate spores could be included in it. If, however, the genus is restricted to Bubák's description, based on the type species

C. Stephensii (B. & Br.) Bubák, there appears to be little or no reason why *Camerosporium Abietis* should be placed in it. According to Bubák, *Camerographium* does not possess true pycnidia and is characterized by flat, hysteriform fructifications opening by a longitudinal slit and containing clathrate-muriform spores. The striking features in *Myxocyclus cenangioides* is the shape of the fructifications, which are hemispherical or sometimes shortly cylindrical, circular in transverse section, reaching a height of about 0·5 mm. and opening by the irregular disintegration of the wall at the apex. The spores when ripe are dark brown, surrounded by a mucous layer partially derived from the swelling of the sporophores and possess usually one, occasionally two vertical septa in some of the horizontal loculi; there are no paraphyses. *M. cenangioides* possesses a distinct hypostroma embedded in the tissues of the host, made up of pale brown fibre-like hyphae while in *Camerographium* the fructifications are described as "*myceliohyalino lateribus ornata*". Clements and Shear (1931) place *Camerographium* in the Hyalodictyae while *Myxocyclus* and *Camerosporium* are placed in the Phaeodictyae, the former genus being distinguished from *Camerosporium* by its mucose spores.

Grove (1937) states that *Camerographium Abietis* has been recorded from Droitwich on *Picea Pinsapo* (=*Abies Pinsapo*) and from Battle, Sussex, on *Picea* (Rhodes). I am informed that the latter specimen cannot be traced in the Rhodes collection either at Kew or at Birmingham. As this is the only record on *Picea* it appears possible that the host was really *Abies* as the fructifications are stated to occur especially "on leaf scars".

The synonymy and distribution of the species is as follows:

Myxocyclus cenangioides (Ell. & Roth.) Petrak. (1927).

Steganosporium cenangioides Ell. & Roth. (in Ellis & Everhart, 1885).

Camerosporium Abietis Wilson & Anderson (1924).

Camerographium Abietis Grove (1937).

On *Abies balsamea*, Pennsylvania, U.S.A. (Ellis & Rothrock); Ontario, Canada (Dearness); and Bergen, Norway (Jørstad).

A. pectinata, Trondhjem, Norway (Jørstad).

A. nobilis, Bergen, Norway (Jørstad).

A. Lowiana, near Edinburgh (Wilson).

A. Pinsapo, Droitwich (Grove).

I wish to express my thanks to the Director of the Royal Botanic Gardens, Kew; Dr C. R. Shear of the Department of Agriculture, Washington, U.S.A.; Dr I. Jørstad, State Mycologist, Oslo, Norway, and Dr C. G. C. Chesters of the Botanical Department, University of Birmingham for assistance in the preparation of this note.

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(*Accepted for publication* 11 *May* 1939)

PROCEEDINGS

Meeting held at University College, London, 28 January 1939.
The President, Mr E. W. Mason, in the Chair.

J. V. Durden, Esq., B.Sc., demonstrated an uncut version of the film "Moulds" taken by Percy Smith, Esq., of Gaumont British Instructional Ltd.

SYMPOSIUM AND DISCUSSION ON ROOT ROTS

S. D. Garrett. Ecology and world distribution of the cereal foot-rot fungi. (Rothamsted Experimental Station, Harpenden, Herts.)

The cereal foot-rot fungi may be considered in this symposium as a microcosm representative of the whole group of root-infecting fungi. In any study of the ecology of the root-infecting fungi, the relation of these organisms to their substratum must be the first consideration. The tissues of higher plants form the natural substrata of these fungi; the course of infection and colonization of the tissues, in the first place determined by the relation between higher plant and primary parasite, is subsequently much modified by the activity of a succession of other micro-organisms. The sequence of events under natural soil conditions in the field may thus be very different from that present in pure culture or other simplified soil conditions in the laboratory or glasshouse.

The relation of fungi in time to the decomposition of plant remains may be set out schematically, as follows:

Healthy, intact plant tissues { Obligate parasites / Semi-obligate parasites } Soil invaders

Healthy, intact plant tissues } Facultative parasites } Soil inhabitants
Diseased and dead plant tissues }
Diseased and dead plant tissues—Saprophytes }

The *soil invaders* comprise those organisms infecting only healthy plant tissues. Active growth in moribund or dead plant tissues is inhibited or severely restricted by nutritional disability in the obligate parasites, e.g. *Plasmodiophora Brassicae*, and by the antagonism and competition of less-specialized micro-organisms in the semi-obligate parasites, such as *Ophiobolus graminis*. In the continued absence of their host plants, such soil invaders must eventually die out from the soil, as originally postulated by Reinking and Manns from their study of the species of *Fusarium* found in tropical soil.

The *soil inhabitants*, on the other hand, include both facultative parasites, capable of invading and colonizing healthy, diseased, and dead plant tissues, and saprophytes, which can colonize only diseased, and dead tissues. Owing to their less specialized nutritional requirements, such fungi are of general occurrence in the soil, and constitute a fungus flora which is remarkably similar in composition over wide belts of the earth's surface, though marked local variations do, of course, occur. In any cultivated soil, therefore, the fungus flora may be modified, but not materially changed, by the particular cropping system.

Amongst the cereal foot-rot fungi, *Ophiobolus graminis*, causing the Take-all or Whiteheads disease of wheat, forms a good example of the semi-obligate parasite, whilst *Fusarium culmorum* is a typical facultative parasite. *F. culmorum* can invade healthy tissues, causing, for example, the well-known seedling blight of various

cereals; it also invades diseased tissues, commonly following primary attack by *Ophiobolus graminis*. Finally, recent work at Rothamsted Experimental Station has shown that this fungus plays an important part in the early decomposition of normal wheat straw when buried in the soil after harvest.

Mary D. Glynne. Fungal invasion of the roots of healthy wheat plants. (Rothamsted Experimental Station, Harpenden, Herts.)

A study of the gradual invasion of the roots of apparently healthy wheat plants by fungi was carried out in two successive seasons. In 1936, twenty samples were taken at ten pace intervals in two fields where wheat was grown under normal rotation. In one field this was done at four-weekly and in the other at six-weekly intervals throughout the growing season. From each sample of ten to twenty plants the healthiest was selected and pieces $\frac{1}{2}$ cm. long were taken from predetermined parts of the seminal and crown roots and from the crown and subcrown internodes. These were surface sterilized by treatment for 1 sec. in 60 % alcohol followed by 2 min. in 0·1 % mercuric chloride. They were then well washed in sterile water, dried on sterile filter paper and plated on potato dextrose agar *p*H 5. In the following season, at monthly intervals, all that could be obtained of the root system of three healthy looking wheat plants growing in a field under rotation were cut up and plated out after surface sterilization. The fungi emerging from the roots in both seasons were recorded and isolated.

In each instance a steady increase in fungal numbers was evident as the season advanced, the numbers being very high by June, when as many as 100 isolations were made from the root system of one plant.

About 50 % of the fungi isolated were sterile forms, some of which occurred very frequently. Many of the remainder were identified with help from the Imperial Mycological Institute. Among these, *Perconia circinata* (Mangin) Sacc., a little known form described by Mangin in 1899, and an apparently new species of *Pullularia*, were of interest and occurred fairly frequently.

There was a tendency for certain fungi to predominate on different parts of the plant, some on roots, others on the crowns and subcrown internodes.

C. J. Hickman. Contribution to the study of strawberry root rot. (Plant Pathological Laboratory, Harpenden, and Field Laboratory Westerham Hill, Kent.)

The work on root rot of strawberries can be discussed conveniently under two main headings, (1) Lanarkshire disease and (2) black root rot.

(1) *Lanarkshire disease*

Lanarkshire disease, or, as it is now commonly called, "red core" disease, was first reported and investigated in Scotland. Since then, this disease has been observed in several localities in England, and what is probably the same disease has been investigated recently in America.

A diseased plant is characterized by an absence of fibrous roots and the occurrence of a reddened and disorganized vascular cylinder in main roots. Above ground, the symptoms associated with this root infection are stunting, browning of the edges of the laminae, inability to produce runners or fruit, and ultimate death.

Mrs Alcock and her collaborators (1930, 1936) in Scotland, put forward the view that the disease was caused by a species of *Phytophthora* and was most severe under wet soil conditions although not confined to such an environment. These workers did not isolate the fungus.

In America, Anderson (1935) described a similar spread of the disease in well-drained loam soil, while Demaree & Darrow (1937) stated that the disease was severe only in wet areas. Bain & Demaree (1938) reported the isolation of a species of *Phytophthora* from "red core" plants and gave proof of its pathogenicity.

At Westerham Hill, Kent, I have investigated "red core" disease, and the following tentative conclusions are put forward after a period of six months' field study of the problem.

(1) The presence of the species of *Phytophthora* is essential for disease to appear. Evidence for this is found in the occurrence of the disease and this fungus only in plants obtained from stocks on land known to be infested with the disease. The spread of the disease and the fungus in this locality has followed the planting of runners from infected stocks.

(2) The disease is governed to a large extent by soil wetness. The disease has consistently appeared in those areas of a bed in which the soil is wet, and it is mainly confined to such areas.

The hypothesis I hold at present is that *Phytophthora* is the primary cause of the disease but that its parasitic activity is largely governed by soil wetness. It is hoped that field pathogenicity experiments with pure cultures of the fungus which I have isolated, will prove or disprove this suggestion.

(2) *Black root rot*

This disease has been investigated by a number of pathologists in America and Canada, but in this country the problem has been but lightly touched, chiefly by Berkeley and Lauder-Thomson (1934).

The disease is characterized by black lesions on new roots, and by blackened and dead roots. Above ground there is dwarfing, lack of vitality and a tendency to wilt during warm weather.

The fungi which have been isolated from roots of affected plants are typically soil fungi, species of *Fusarium*, *Rhizoctonia*, *Pythium*, *Cylindrocarpon*, *Coniothyrium*, *Hainesia*, *Alternaria*, *Verticillium*, and *Pachybasium* being perhaps the most common. There is a general agreement between investigators regarding the genera of fungi isolated from affected plants but there is no such agreement regarding their importance in relation to black root rot.

Wild strawberries have been described as affected with a black root rot having a similar fungal flora associated with it. It is possible that with intensive cultivation of the plant these soil-inhabiting fungi have been able to increase in number and, becoming parasitic under conditions unfavourable for the plant, to give rise to black root rot.

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P. H. Williams. Root rots of glasshouse plants. (Experimental and Research Station, Cheshunt.)

In tomato seedlings and young pot plants, species of *Phytophthora* often cause a rot of the tap-root and of the lateral roots. This condition is known as "Toe-rot" and is of much importance in Scotland. *Thielaviopsis basicola* also attacks the roots at this stage, and in seasons when the light is poor and the growth of the plant slow, it may do much damage. Even badly stunted plants will often recover if conditions improve.

After planting out, *Colletotrichum atramentarium* is the only important root-rot fungus, although *Thielaviopsis* and *Phytophthora* also occur. Species of *Fusarium* are also commonly present in diseased tomato roots but their exact role is uncertain. The two eelworms, *Heterodera marioni* and *H. schachtii*, while not rotting the roots directly, cause swellings and deformations which interfere seriously with the uptake of water.

Tomatoes in the border may lose their roots from certain physical causes. Planting in cold soil often causes a severe check to the plant and the loss of the tap-root. Later in the season, incautious watering may result in waterlogging of the soil with consequent death of the roots.

As a remedial measure during the growing season mulching is of great benefit. Peat moss is used widely for this purpose, a layer of moist peat about 1½ in. thick being applied. The plants root into this in about ten days and are then fed with artificial manures. Surface roots to replace the damaged roots may also be encouraged by the use of a mulch of stable manure.

Mulches, while enabling the grower to keep his plants alive, do not touch the cause and, if parasitic fungi are concerned, soil sterilization is necessary. Formaldehyde at 2 % strength applied at the rate of 50 gal. of the dilute solution to about 12 sq. yd., is widely used. Cresylic acid is also employed. Steam sterilization is the most efficient method because in addition to killing the parasites, it produces physical and chemical changes in the soil which liberate large quantities of food materials. This results in a saving in manures in the following season which partly offsets the cost of the treatment.

In the cucumber, the tap-root is frequently affected and the rot often starts at the point of insertion of a lateral root. The roots themselves may also become diseased. A large number of fungi and bacteria are present in the decayed tissue. Tests of species of *Fusarium* isolated from cucumber roots have been made recently and none of these fungi appears to be an active parasite. Possibly, tests of other organisms may show that some are capable of rotting the roots of cucumbers. At present it seems that the causes of this disease are mainly cultural in origin.

It has been found that cucumbers are very sensitive to waterlogging of the soil, the roots dying when they penetrate the wet soil at the bottom of pots standing in water. Under nursery conditions, the tip of the tap-root often dies soon after potting and it appears likely that when the plants are watered in, the soil at the bottom of the pot remains over-wet and that this kills the roots. Poor light and low temperatures which retard growth may aggravate this condition.

After planting in the border, beds which settle tightly or are badly drained are a constant source of trouble, the roots dying and the tap-root and the base of the stem rotting. The remedy lies in drying out the bed by withholding water and ventilating freely, the foliage being maintained by syringing. After a week or ten days the beds are top-dressed and the normal forcing process can be resumed.

L. Ogilvie. Root rots of hardy vegetables. (Long Ashton Research Station.)

Five important diseases prevalent in the Evesham market-gardening area of Worcestershire, namely, the *Fusarium* foot rot of dwarf beans (*F. Solani* var. *Martii* f. 3), the *Fusarium* foot rot of peas (*F. Solani* var. *Martii* f. 2), the *Fusarium* foot rot of leeks (*F. culmorum*), the violet root rot of asparagus (*Rhizoctonia Crocorum*) and the white rot of onions (*Sclerotium cepivorum*) were discussed in relation to certain environmental factors.

Soil infestation. These diseases occur severely only where there has been intensive cultivation of the host plants over a long period and where there is little rotation. In peas, foot rot, usually accompanied by the eelworm *Heterodera schachtii*, occurs only in the areas in Worcestershire where peas have been long cultivated, and not at the edges of the market-gardening area. In the Worcestershire pea area there is a rotation usually only of sprouts. In West Somerset, where there is a four-course

rotation, the disease is not at all prevalent. The *Fusarium* is very widespread, but symptoms are severe apparently only where the inoculum potential is large. The same applies to the other diseases; each is most severe where the host plant is most cultivated.

It is well known that there may be strains of pathogenic organisms of different degrees of virulence, and in these areas of intensive cultivation the highly pathogenic strains may be more liable to become established.

The fungus may sometimes be carried over from season to season by some other plant which is only slightly attacked. Thus D. L. G. Davies found that the leek foot rot strain of *F. culmorum* could attack cereals slightly.

Spread. The spread of certain of these diseases is sometimes difficult to explain. Thus infection by *Rhizoctonia Crocorum* sometimes begins in the middle of a field otherwise free. Possibly pieces of infested soil are carried on the feet of birds which feed on the asparagus berries.

Soil moisture. Pea and dwarf bean foot rots are apparently favoured by heavy rainfall early in the summer at the beginning of infection. This is true of several diseases caused by *Fusarium*. On the other hand, onion white rot is favoured by a dry soil, at about 40 % moisture-holding capacity, and is greatly reduced when this is as much as 60 to 80 %. It occurs, therefore, especially during dry periods, as at the end of the summer of 1938.

Temperature. Most species of *Fusarium* have an optimum temperature for growth of about 26–28° C., as with those in question. These diseases are most severe in the height of summer and in warm seasons. Pea foot rot is called Sancta-Johannis Krankheit, because the symptoms are evident about St John's Day, 24 June. In D. L. G. Davies's experiments he could get seedling damage with *F. Solani* v. *Martii* f. 2 out-of-doors only in the summer.

Rhizoctonia Crocorum also develops most rapidly at the end of the summer. The optimum temperature for growth of *Sclerotium cepivorum* is 60–75° F., but the disease develops most rapidly at 50–68° F., which are end of summer temperatures.

Soil type. Pea and dwarf bean foot rots are impartial to soil type, occurring on heavy and on light soils. White rot seems to prefer clay soils.

Effect of fertilizers, etc. Pea and dwarf bean foot rots are worse where dung is applied, and less severe where inorganic nitrogen in applied. Applications of sulphate of ammonia or nitro-chalk to the young plants enable them to throw out fresh roots so that they outgrow the disease. Onion white rot, on the other hand, appears to be less severe following applications of dung.

Control. Control measures include the use of resistant varieties or strains, as in peas and dwarf beans; long rotations; clean cultivation, free from weeds, as in violet root rot of asparagus; and the use of appropriate fertilizers.

Dr Bisby, Dr Brett, Prof. Brown, Mr Buddin, Miss Cayley, Dr Harrison, Mr Keyworth, Mr Mason, Mr Preston, Miss Sampson, Mr Samuel, Miss Wakefield, Dr Wormald and the five contributors to the Symposium took part in the Discussion which followed.

(*Accepted for publication* 20 *April* 1939)

UROCYSTIS VERSUS *TUBURCINIA*

A PROPOSAL for the conservation of the name *Urocystis* Rabenh. has been drawn up by the Plant Pathology Committee of the British Mycological Society (Secretary: G. C. Ainsworth), and forwarded to Dr C. L. Shear, the Secretary of the Special Committee for Fungi, appointed at the International Botanical Congress, Amsterdam, 1935.

The name *Tuburcinia* has precedence, and is the legal name according to the International Rules of Botanical Nomenclature.

The Plant Pathology Committee proposed that the name *Urocystis* Rabenh. (1856) be conserved against the name *Tuburcinia* Fr. (1832) for the following reasons:

(i) The name *Urocystis* has been well known to, and in frequent use by, plant pathologists since there has been a science of plant pathology, and should accordingly not be discarded without cogent reasons.

(ii) The disuse of the name *Urocystis* is not dictated by the accession of any new knowledge. It has been known and accepted that *Tuburcinia Orobanches* is a species of *Urocystis* since 1877, when it was renamed *Urocystis Orobanches*. For more than forty years mycologists refrained from transferring the species of *Urocystis* en bloc to *Tuburcinia*, so as not to confuse the literature.

(iii) Since 1887, the generic name *Tuburcinia* Fr. has been used in a rather different sense, as if it were founded on *T. Trientalis* Berk. & Br., a species unknown to Fries. It is still a matter of taxonomic dispute whether species of *Tuburcinia* so used (and none of them are major pathogens) are properly classified in the same genus with the species of the genus *Urocystis*.

It is strongly urged that it is not in the interests of plant pathology that major pathogens such as *U. occulta*, *U. Tritici* and *U. Cepulae* should be dispossessed of a well known and long established generic name that has always been free from any taint of nomenclatural confusion, in order to be given a less known one, the use of which since 1887 is open to suspicion.

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NOMINA GENERICA CONSERVANDA

CONTRIBUTIONS FROM THE NOMENCLATURE COMMITTEE OF THE BRITISH MYCOLOGICAL SOCIETY. I

(Secretary: E. M. Wakefield)

In an endeavour to secure uniformity within the British Empire in the application of common names of plant diseases, the Plant Pathology Committee of the British Mycological Society published in 1929 a *List of Common Names of British Plant Diseases*. A second edition was issued as a separate booklet in 1935. In the list were also included the Latin names of the pathogens, and as far as possible these were cited in accordance with the International Rules of Botanical Nomenclature. Recently, the Committee has secured agreement from about forty Societies, Institutes, Editors of Journals, etc., within the British Isles to use in their publications the fungus binomials recommended in this *List*, on the understanding that the *List* will be frequently revised.

This step has made the Committee more than ever conscious of the urgent need for international agreement about the conservation of generic names which are in common use but which are not in accordance with the Rules. As is well known, strict adherence to any code of nomenclature sometimes involves name changes which are very distasteful to the large body of field botanists and to workers in applied botany. There can be no list of conserved specific names, since proposals for *nomina specifica conservanda* were rejected by large majorities both at Cambridge in 1930 and at Amsterdam in 1935. For generic names, however, there is in the International Rules the principle of *nomina generica conservanda*, first passed at the Vienna Congress in 1905, which provides for the continuance of selected well known and widely used generic names as exceptions to the normal working of the Rules. Proposals for the conservation of such names must be examined by the special international committees appointed to deal with the groups of plants in question, and if approved the names are conserved and are confirmed at the next International Congress. For the purpose of elaborating a list of fungus names for conservation, a special committee was appointed at the Brussels Congress in 1910, with Prof. Réné Maire as "Redacteur".

Because of the international situation no Congresses were held in

1915 or 1920, and in 1926 the executive committee of the Ithaca Congress waived the right to decisions on problems of nomenclature because some countries were not represented at that Congress. Consequently the first collected list of proposals for the conservation of generic names of fungi did not appear until 1930, when three lists were published in the *Recueil Synoptique* of proposals to be submitted to the International Botanical Congress at Cambridge in that year. At Cambridge another special mycological committee was appointed to examine these proposals, but up to 1935 nothing was done. A third special committee was appointed at Amsterdam in 1935, with Dr C. L. Shear as secretary, but it is known that up to the present it has been impossible to procure voting on the proposals by members of this committee because the necessary preliminary investigations have not been carried out.

The Council of the British Mycological Society, at the request of its Plant Pathology Committee, decided that a small committee should be formed to investigate problems of nomenclature and to state the case for and against some of the more important proposals before the next International Botanical Congress, which is to meet at Stockholm in 1940.

For this purpose the Council appointed Mr E. W. Mason and Miss E. M. Wakefield as a nucleus, giving them power to co-opt members as required and to start work at once. Miss Wakefield agreed to act for the time being as secretary to the committee. In forming the committee it was decided to invite first, all those who were known to be preparing lists of British fungi in connexion with a scheme initiated by the Plant Pathology Committee, and to add several members who were chosen especially because they could attend meetings regularly and could undertake some of the examination of literature which would be required. The Committee at present consists of Mr E. W. Mason (Chairman), Miss E. M. Wakefield (Secretary), Dr G. R. Bisby, Dr C. G. C. Chesters, Mr W. P. Findlay, Mr W. C. Moore, Dr Alex Smith and Miss F. L. Stephens.* At the first meeting its work was defined as "to produce and co-ordinate material which is prerequisite for solving the most urgent problems of nomenclature". It was agreed that the most pressing need is decision on proposed *nomina generica conservanda*, and particularly on those which necessitate agreement with the international special committees concerned with other groups of plants. Accordingly, those names in the published lists which are later homonyms of names of plants in other groups were selected for examination. Since last February the Committee has completed statements of the cases for and against conservation for these later homonyms and for

* Miss K. Sampson prepared the statement for *Urocystis* versus *Tuburcinia* (p. 223).

a number of other names proposed, and has forwarded these to Dr Shear. It has also been decided to publish these statements, in the hope that they will prove helpful to the International Special Committee for Fungi. This first contribution, includes fourteen names, of which eight are later homonyms and two, *Urocystis* and *Barya*, are additional to those published in the 1935 edition of the International Rules. The names other than homonyms have been selected either because of their importance to workers in applied mycology or because they were of special interest to some members of the Committee. Preparation for publication has involved some alteration in wording of the statements as originally sent to Dr Shear.

In the preparation of lists of *nomina conservanda* two principles are involved, namely the conservation of certain names against competing earlier and valid names, and the selection of suitable types, lectotypes or "standard species", which will fix the application of the names conserved. For guidance as to principles and methods of stating the cases for and against conservation, the Committee has relied mainly on the work of phanerogamists on the "Conservation of Later Generic Homonyms" (1935) and on Dr Sprague's proposal for the conservation of 90 additional names submitted to the Cambridge Congress (1930). In the absence of Rules for the selection of types, the Committee has been guided by the principles used by phanerogamists, in particular the list of "Standard Species of Linnean Genera of Phanerogamae", by A. S. Hitchcock and M. L. Green, published in the *Proposals of British Botanists* which was prepared for the Cambridge Congress (1930). It is not claimed that the statements here set out are final. Difficulties have been encountered, particularly in the problem of selecting types, and sometimes, as in *Flammula*, it has seemed that the taxonomy of the genus is not yet sufficiently understood to enable a satisfactory selection to be made. Statements of the facts for selected names were prepared by individual members of the Committee. Each statement was then read before the full Committee and discussed thoroughly. The recommendations, as here given, are those agreed upon after such discussion. Criticism, both of matter and of method of presentation, will be welcomed, as only by such means can international agreement finally be secured.

The Committee is deeply indebted to Miss M. L. Green and Dr T. A. Sprague for friendly interest and valuable guidance throughout the work.

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BARYA Fuck. (1869) versus *Barya* Klotzsch (1854)

Barya Klotzsch in *Monatsber. Berl. Akad.* 122 (1854); and in *Abh. Akad. Berl.* 22, t. 2 (1854) (Begoniaceae).

Barya Klotzsch is a synonym of *Begonia* Linn. and has been little used as a generic name. It was used by Irmscher (Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, XXI, 583 (1925)) as a name for section 44 of *Begonia*, with three species in Peru and Bolivia.

Barya Fuck. *Symb. Mycol.* 93 (1869) (Hypocreaceae).

This name for a genus of fungi has been accepted in all mycological floras up to the present date which have included Hypocreaceae: Saccardo, *Syll. Fung.* II, 563 (1883); Winter in Rabenhorst, *Kryptogamen-Fl. Deutschl.* I, ii, 93 (1885); Lindau in Engler & Prantl, *Nat. Pflanzenfam.* I, i, 362 (1897); Lind, *Danish Fungi*, 174 (1913); Migula, *Kryptogamen-Fl. Deutschl.* III, iii, 760 (1913); Seaver in *North Amer. Flora*, III, 47 (1910); Keissler in Rabenhorst, *Kryptogamen-Fl. Deutschl.* VIII, 292 (1930); Clements & Shear, *Genera of Fungi*, 81 (1931); Petch, "British Hypocreales", in *Trans. Brit. Mycol. Soc.* XXI, 284 (1938).

Type species: *Barya parasitica* Fuck., the only species mentioned when the genus was proposed. The genus includes about six species, none of which are of economic importance.

Recommendation. As phanerogamic botanists do not use the generic name *Barya* Klotzsch, while mycologists have for many years used the name *Barya* Fuck., and, in default, will have to coin a new name for it, it is recommended that *Barya* Fuck. (1869), with type species *Barya parasitica* Fuck., be conserved against *Barya* Klotzsch (1854).

GUIGNARDIA Viala & Ravaz (1892) versus *Carlia* Bon. (1864) (nec Rabenhorst (1857))

Guignardia Viala & Ravaz in *Bull. Soc. Mycol. Fr.* VIII, 63 (1892).

The name *Guignardia* was proposed by Viala & Ravaz as a substitute for *Laestadia* Auersw. (1869), which was found to be a later homonym of *Laestadia* Kunth (in Lessing, *Syn. Compos.* 203 (1832)), a genus of Compositae. The type species is *Guignardia Bidwellii* (Ellis) Viala & Ravaz (syn. *Laestadia Bidwellii* (Ellis) Viala & Ravaz).

Carlia Bon. *Abhandl.* 152 (1864).

The genus *Carlia* was first proposed by Rabenhorst, in Klotzsch, *Herb. viv. mycol.* ed. 2, no. 567 (1857), with one species, *C. Oxalidis* Rabenh., which is therefore the type.

The name was taken up by Bonorden (*loc. cit.*), who recognized three species: *C. Oxalidis* Rabenh., *C. maculiformis* (Fr.) Bon. and *C. Laburni* Bon.

Neither Rabenhorst nor Bonorden stated whether the ascospores were septate or not, but Bonorden figured those of *C. maculiformis* and *C. Laburni* as aseptate. Saccardo (*Syll. Fung.* I, 429 (1882)) decided that those of *C. Oxalidis* were aseptate, and mistakenly compiled the species as *Laestadia Oxalidis* (Rabenh.) Sacc., whereas the spores are one-septate and the fungus is a species of *Sphaerella*.

O. Kuntze (*Rev. Gen. Pl.* II, 846 (1891)) pointed out that *Laestadia* Auersw. was a later homonym of *Laestadia* Kunth and therefore invalid; relying on Saccardo's placing of *Carlia Oxalidis* in *Laestadia* he proposed to adopt *Carlia* Rabenh. (1857) as the valid name for *Laestadia* Auersw.

Magnus (*Oesterr. bot. Z.* XLIV, 203 (1894)) put forward the view that Bonorden gave a more exact description of *Carlia* Rabenh., and that his second species *C. maculiformis* was a species of *Laestadia* Auersw.; hence that the genus could properly be cited as *Carlia* (Bonord. emend.) Kuntze (syn. *Laestadia* Auersw. non Kunth, *Guignardia* Viala & Ravaz). Magnus used the name thus in Dalla Torre & Sarntheim, *Flora der Tirol*, III, 468 (1905), including three species, but the emended name has not been taken up by any other author.

Since the adoption of the type-species method of fixing the application of generic names, Magnus's proposal appears unacceptable. The monotypic *Carlia* Rabenh. cannot become another genus as the result of the addition by Bonorden of two further species. *Carlia* Bon. could only become a valid genus if it were conserved against *Carlia* Rabenh.

Recommendation. It is recommended that *Guignardia* Viala & Ravaz be accepted as the valid name for the genus previously called *Laestadia* Auersw., and therefore in no need of conservation against *Carlia* Bon., which has no valid existence.

Nummularia Tul. (1863) versus *Nummularia* Gronov. (1762) and *Biscogniauxia* O. Kuntze (1891)

Nummularia Gronov. *Fl. Virg.* ed. 2, 26 (1762) (Primulaceae).

Nummularia Gronov. is a synonym of *Lysimachia* Linn. and has covered about five species. The name survives as that of a section of *Lysimachia* in Pax. & Knuth, Primulaceae 257, in Engler, *Pflanzenreich*, IV, 237 (1905), with six species, ranging from Europe to China.

Nummularia Tul. *Sel. Fung. Carp.* II, 42 (1863) (Xylariaceae).

The name *Nummularia* Tul. has been accepted in all mycological floras which have included the Xylariaceae, as: Nitschke, *Pyren. Germ.* 54 (1867); Karsten, *Mycol. Fenn.* II, 5 (1873); Saccardo, *Syll. Fung.* I, 295 (1882); Winter in Rabenhorst, *Kryptogamen-Fl. Deutschl.* I, ii, 846 (1887); Ellis & Everhart, *North Amer. Pyren.* 621 (1892); Lindau in Engler & Prantl, *Nat. Pflanzenfam.* I, i, 481 (1897); Schroeter, *Pilz. Schles.* II, 457 (1897); Traverso in *Flor. Ital. Crypt.* Pyrenomycetae, 56 (1906); Lind, *Danish Fungi*, 252 (1913); Migula, *Kryptogamen-Fl. Deutschl.* III, iii, 661 (1913); Clements & Shear, *Genera of Fungi*, 65 (1931); Miller, "British Xylariaceae", II, in *Trans. Brit. Mycol. Soc.* XVII, 132 (1932).

The genus *Nummularia* contains over one hundred species, of which only *N. discreta* (Schw.) Tul. is of economic importance. (*N. discreta* has been indexed in ten volumes of *Rev. Appl. Mycol.*) The genus was founded with three species, *N. Bulliardi* Tul. (syn. *Hypoxylon nummularium* Bull.), *N. discreta* (Schw.) Tul., and *N. dryophila* Tul., which last has apparently not since been recognized. *N. Bulliardi*, as its synonym shows, suggested the generic name, and so may be regarded as the type; and if the genus is divided, it is the best-known representative of the group of species characterized by convex disks to the stromata (the largest section). *N. discreta* is the best-known representative of the smaller group of species, characterized by having concave disks to the stromata.

Miller (*loc. cit.*) contends that the larger section typified by *N. Bulliardi* falls naturally into *Hypoxylon* and is not worth retaining; he would conserve the name

Nummularia with *N. discreta* as lectotype. Shear (*Mycologia*, xxx, 580 (1938)) maintains that both sections form a natural genus, which is best typified by *N. Bulliardi* Tul.

Biscogniauxia O. Kuntze, *Rev. Gen. Pl.* I, 398 (1891).

This name was proposed by O. Kuntze as a substitute for *Nummularia* Tul., which he pointed out to be a later homonym of *Nummularia* Gronov. and therefore invalid. If *Nummularia* Tul. be not conserved, the valid name for the fungal genus is *Biscogniauxia* O. Kuntze. This name has never been taken up.

Recommendation. Since the essential is to have this well-known name conserved for mycological use, it is recommended that *Nummularia* Tul., with *N. Bulliardi* Tul. as type, be conserved against *Nummularia* Gronov., and that *Biscogniauxia* O. Kuntze be rejected.

Sphaerella (Fr.) Rabenh. (1856) versus *Sphaerella* Ces. & de Not. (1863), emend. Sacc. (1875), *Sphaerella* Sommerf. (1824), *Carlia* Rabenh. (1857) and *Mycosphaerella* Johans. (1884)

Sphaerella Sommerf. in *Mag. f. Naturvidenskap.* IV, 249 (1824) (Algae).

This genus was founded with three species: *S. nivalis*, *S. Wrangelii* (syn. *Volvox lacustris* Girod, 1802) and *S. botryoides*. It was discussed from the mycological standpoint by Grove (*J. Bot.* I, 89–92 (1912)). As he left it, two courses were open to algologists: (1) to accept *S. nivalis* as the type species, which would mean transferring all the species of the large genus *Chlamydomonas* to *Sphaerella*, or (2) to accept *S. Wrangelii* as the type. Apparently the second course has been followed, and the genus is maintained chiefly for the species which is now called *S. lacustris* (Girod) Wittrock.

Carlia Rabenh. in Klotzsch, *Herb. viv. mycol.* ed. 2, no. 567 (1857).

The genus was founded with the single species *Carlia Oxalidis* Rabenh. on *Oxalis*. This was recognized as a species of *Sphaerella* and transferred as *S. Carlii* Fuck. in 1869 (Fuckel, *Symb. Mycol.* 103). With regard to Rabenhorst's diagnosis Fuckel wrote: "Gott weiss was Rabenhorst unter dem Mikroskop gehabt!" H. & P. Sydow (*Ann. Mycol.* XVII, 45 (1919)) suggested that Rabenhorst included a description of some *Torula pinophila* that had fallen on to the leaves of the host plant. The species is now alternatively cited as *Sphaerella depazeiformis* (Auersw.) Ces. & de Not. or *Mycosphaerella depazeiformis* (Auersw.) Lindau.

Von Höhnel (*Ber. dtsch. bot. Ges.* XXXV, 624 (1917)) accepted *Carlia* Rabenh. as supplying the earliest correct generic name for all the species now cited as either *Sphaerella* or *Mycosphaerella*. The piecemeal transfer to *Carlia* now affects perhaps twenty species.

Sphaerella Ces. & de Not. in *Comment. Soc. Critt. Ital.* I, iv, 236 (1863).

The name *Sphaerella* first occurs as that of a subgenus of *Sphaeria* (Fries in *Summ. Veg. Scand.* II, 395 (1849)). Seven species were included, of which five, as pointed out by von Höhnel, would certainly or almost certainly come within the definition of the genus *Sphaerella* Ces. & de Not., emend. Sacc. In 1856, one of the species, *Sphaeria punctiformis* Pers., was transferred to *Sphaerella* by Rabenhorst (*Herb. viv. mycol.* ed. 2, no. 264) as *S. punctiformis* (Pers.) Rabenh., and it is submitted that this transfer raised the subgenus *Sphaerella* Fr. to generic rank. The subgenus was again raised to generic rank by Fuckel (*Symb. Mycol.* 99 (1869)) as *Sphaerella* (Fr.) Fuck.

Fuckel, however, overlooked the fact that Cesati & de Notaris (*loc. cit.*) in 1863 had erected a genus *Sphaerella*, apparently independently of Fries's subgenus. *Sphaerella* Ces. & de Not. was founded with twenty-five species. The ascospores were described as one- or three-septate. The name was taken up by Cooke in

J. Bot. IV, 245 (1866), and by Auerswald in Gonnermann & Rabenhorst, *Mycologia Europaea*, V and VI, 1 (1869). Saccardo (*Conspectus generum Pyrenomycetum*, 9 (1875)) restricted the name to species with one-septate spores, and cited three species as examples, *S. sparsa* (Wallr.) Auersw., *S. punctiformis* (Pers.) Fuck. and *S. Rumicis* (Desm.) Fuck. In this sense the name came into Saccardo's *Syll. Fung.* I, 476 (1882) with 279 species, and in successive volumes the number has now reached 950. The name was also used in this sense by Karsten, *Rev. Mon. Ascomycet.* 63 (1885); Winter in Rabenhorst, *Kryptogamen-Fl. Deutschl.* I, ii, 355 (1885); Ellis & Everhart, *North Amer. Pyren.* 264 (1892); Kirschstein in *Kryptogamen-Fl. Mark Brandenb.* VII, 325 (1938).

As noted above, the first fungal species to be placed in *Sphaerella* was *S. punctiformis* (Pers.) Rabenh. (1856). This was one of the species of Fries's subgenus, and, as *S. sparsa* is a synonym, it represents two out of the three examples given by Saccardo when he restricted the genus, as conceived by Cesati & de Notaris, to species with one-septate ascospores. As Fries's subgenus is virtually the same as the genus conceived by Cesati & de Notaris and emended by Saccardo, the simplest plan seems to be to take *S. punctiformis* (Pers.) Rabenh. as the lectotype, and to cite the genus as *Sphaerella* (Fr.) Rabenh., for, in effect, Rabenhorst did raise the subgenus to generic rank.

Mycosphaerella Johanson, Svamp. fr. Island, in *Svenska Vetensk. Akad. Forhandl.* no. 9, 163 (1884).

This name was proposed, with twelve species enumerated, to replace *Sphaerella* Ces. & de Not., a later homonym. Included was *Mycosphaerella polyspora* Johans., a species with sixteen ascospores in each ascus; the rest were transfers from *Sphaerella*.

Mycosphaerella has grown to a large (but unknown) size by casual transfers from *Sphaerella* Ces. & de Not., as well as by the addition of new species, which are still being compiled into Saccardo's *Sylloge* under *Sphaerella*. The name was accepted by Starbäck (*Bih. K. Svenska Vet. Akad. Handl. Stockholm*, XV, iii, nos. 2, 9 (1889)), who transferred nine species; Schroeter, *Pilz. Schles.* II, 333 (1894), who claimed to transfer thirty-six species; Oudemans, *Rev. Champ. Pays-Bas*, II, 205 (1897), where twenty-six species are listed and the transfer of twenty-five incorrectly attributed to Johanson; Oudemans in *Cat. rais. Puys-Bas*, 247 (1904), where most transfers are incorrectly attributed to Johanson and Magnus; Lindau in Engler & Prantl, *Nat. Pflanzenfam.* I, i, 423 (1897), with 102 species, of which he claimed to transfer seventy; Lindau in *Hilfsbuch*, II (1903), with an unknown number of species and no authorities for each change; Magnus in Dalla Torre & Sarntheim, *Flora der Tirol*, III, 463 (1905), in which he claimed to transfer twenty-five species; Lind, *Danish Fungi*, 202 (1913), with eighty-five species, fifteen of which were transferred by him; Migula, *Kryptogamen-Fl. Deutschl.* III, iii, 269 (1913), with 145 species, for fifty-one of which he gave no authorship.

For many years *Mycosphaerella* has been accepted among mycologists who use the Scandinavian, the English, and (until Kirschstein in 1938 reverted to the use of *Sphaerella*) the German languages. Nearly all the cultural work has been described under the name *Mycosphaerella*, as, for instance, by Klebahn (*Haupt- und Nebenfruchtformen der Askomyzeten* 1918) in Germany and by Higgins and his associates in the United States of America. But during this time no monographic treatment of the genus has appeared except in German.

Mycosphaerella was rejected by Saccardo (*Syll. Fung.* IX, 659 (1891)) as a substitute name for *Sphaerella*, but maintained with a single species, *Mycosphaerella polyspora* Johans., to accommodate species of *Sphaerella* with polysporous asci.

Summary. The name *Sphaerella* was first used as a generic name by Rabenhorst in 1856, when he issued a dried specimen of *S. punctiformis* (Pers.) Rabenh. in Klotzsch, *Herb. viv. mycol.* ed. 2, 264. The subgenus *Sphaerella* of Fries was again raised to generic rank by Fuckel in 1869, but in the meantime the genus *Sphaerella* Ces. & de Not. (1863) had been proposed, including species with spores one- to three-septate. Saccardo (1875) limited the genus of Cesati & de Notaris to species with

one-septate spores, and this is the citation now usually given for the genus in question. The competing names are *Carlia* Rabenh. (1857) and *Mycosphaerella* Johans. (1884). If, as suggested, the generic name *Sphaerella* is dated from Rabenhorst's use of it in 1856, *Carlia* becomes invalid and need not be considered. *Mycosphaerella* Johans. now covers a large number of species.

In 1910, Saccardo proposed that *Sphaerella* Ces. & de Not. should be conserved against *Sphaerella* Sommerf. (see *Rec. Doc. Int. Bot. Congr. Bruxelles* (1910)), and since that date he and his successors, in the compilation of the *Sylloge Fungorum*, have been waiting for the decision of an International Botanical Congress. During this time they have been transferring the new species of *Mycosphaerella* to *Sphaerella*. The result is that the authorities of nearly all the species of *Sphaerella* can be correctly cited by anyone who has access to the *Sylloge*. The species of *Mycosphaerella*, on the other hand, have never been properly compiled; for over fifty years there have been transfers (witting or unwitting) to *Mycosphaerella* in floristic, pathological, general and other papers, and also in exsiccata. No one can nowadays ensure that he is citing correctly the authority for many species of *Mycosphaerella*.

Recommendation. The conservation of the name *Sphaerella* for mycological use will save much unproductive labour, and will cause few difficulties. It is therefore recommended that it be accepted that Rabenhorst raised Fries's subgenus to generic rank when he made the combination *S. punctiformis* (Pers.) Rabenh., that *Sphaerella* (Fr.) Rabenh. (1856), with type species *S. punctiformis* (Pers.) Rabenh., be conserved against *Sphaerella* Sommerf. (1824), and that *Mycosphaerella* Johans. (1884) be rejected. *Carlia* Rabenh. (1857) is invalidated if *Sphaerella* (Fr.) Rabenh. (1856) be accepted.

Uromyces Link (1816) versus *Nigredo* Roussel (1806), *Caeomurus* (~~Link~~) S. F. Gray (1821) and *Pucciniola* Marchand (1829)

The proposal to conserve the name *Uromyces* occurs in two forms in the lists of *nomina generica conservanda* published as an appendix to the International Rules, 1935.

(1) In Prof. Maire's list it is given as "*Uromyces* Tul., *Ann. sci. nat.* (4), II, 145 (1854)" with type *Uromyces Betae* (Pers.).

(2) In the lists of Prof. J. C. Arthur and Dr Shear it is given as "*Uromyces* [Link, *Ges. Nat. Freunde Berlin Mag.* VII, 28 (1815)] Unger, *Exanth. Pfl.* 277 (1833)", with type *U. appendiculatus* Unger.

Nigredo Roussel, *Fl. Calvados*, ed. 2, 47 (1806).

This name was proposed with a very brief description, and no binary combinations were made. The species cited were *Uredo Betae* Pers., *U. suaveolens* Pers., *U. Viciae-Fabae* Pers. and *U. Anemones* Pers. The genus was taken up by Arthur in the *North American Flora*, but has since been discarded by him in favour of *Uromyces*, which he proposes for conservation.

Uromyces.

The name *Uromyces* first occurs in Link, *Obs.* II, 28 (1816), where it is given as a subgenus of *Hypodermium*, a name he had substituted for *Caeoma*, used in his earlier work. A careful examination of Link's treatment of his subgenera, however, shows that he used them as genera, since under each he made the proper binary combinations. This point has been overlooked, no doubt, because he abbreviated both *Uredo* and *Uromyces* as "*Ur.*" Since *Uredo* is of feminine gender and *Uromyces* masculine it is easy to see that Link intended the combinations under *Uromyces* to bear that name, for he has "*Ur. appendiculatus*", whereas the names given under his subgenus *Uredo* bear epithets with feminine terminations. The point is further proven by the fact that under the subgenus *Aecidium* he has binary combinations, using *Aecidium* as the generic name (*loc. cit.* p. 29). These binary combinations may be regarded as giving the date of the generic name for purposes of nomenclature.

Uromyces as a generic name may therefore be dated from Link, *Obs.* II (1816). There is also little doubt that Link included the teleutospore stage in his conception of the genus, since he cited his earlier name *Caeomurus* as a synonym, and this included the "Pucciniés à une loge" of De Candolle. Further, Persoon's description of *Uredo appendiculata* and its varieties indicates that teleutospores were included.

The type species of the genus is *Uromyces appendiculatus* Link, the only one of the species included in 1816 which now remains in the genus.

Caeomurus S. F. Gray (*Nat. Arr. Brit. Pl.* 541 (1821)) and *Pucciniola* Marchand (*Bijdr. Nat. Wet.* IV, 47 (1829)) are invalid if *Uromyces* is dated from 1816.

Recommendation. As *Nigredo* Roussel is not now used, and the name *Uromyces* is well known and universally used in floras and by plant pathologists, it is recommended that *Uromyces* Link (1816) be conserved against *Nigredo* Roussel (1806). It is not necessary to conserve against *Caeomurus* (1821) and *Pucciniola* (1829), since these are later synonyms.

Urocystis Rabenh. (1856) versus *Tuburcinia* (Fr.) (1832)

Tuburcinia Fr. *Syst. Mycol.* III, 439 (1832).

The genus was described with three species, *Tuburcinia Orobanches* (Mérat) Fr. on *Orobanche ramosa* L., *Tuburcinia Monotropae* Fr. and *T. punctiformis* (DC.) Fr. According to Liro (1922) the second and third species are unrecognizable, and therefore *T. Orobanches* (Mérat) Fr. should be chosen as the type. This has spore balls with clear cortical cells.

In 1850, *T. Trientalis* Berk. & Br., on *Trientalis europaea*, was added to the genus (*Ann. Mag. Nat. Hist.* (2), V, 464). According to Woronin (*Abh. Senck. Nat. Ges.* XII, 359–591 (1882)) the spores of the ball in this species are all alike, and his figures clearly show germ-tubes issuing from the superficial cells. Subsequent writers up to 1922 used the name *Tuburcinia* as emended by Woronin, giving *T. Trientalis* Berk. & Br. as the type species of the emended genus. In this sense the name is used in Plowright, *British Uredineae and Ustilagineae* (1889); Dietel in Engler & Prantl, *Pflanzenfam.* I, i, 19 (1897), and in ed. 2, VI, 19 (1928); Clinton, "North American Ustilagineae", in *Proc. Bost. Soc. Nat. Hist.* XXXI, 446 (1904); Schellenberg, *Die Brandpilze der Schweiz*, 151 (1911); Lindau in *Kryptogamen-Fl. Mark Brandenb.* V*a*, iii, 52 (1914); Zundel in *Bothalia*, III, 312 (1938).

Urocystis Rabenh. in Klotzsch, *Herb. viv. mycol.* ed. 2, no. 393 (1856).

The name was substituted for *Polycystis* Lév., which was a later homonym of the name of an algal genus. The type species is *Urocystis occulta* (Wallr.) Rabenh., the only one mentioned when the generic name was proposed. Many species have since been added, among them *Tuburcinia Orobanches* (Mérat) Fr., which was transferred to *Urocystis* by Fischer v. Waldheim in 1877. The name *Urocystis* was used in all countries up to 1922 and appears in an extensive literature dealing with important pathogens. About thirty to forty species have been described.

In 1922, Liro ("Über die Gattung *Tuburcinia* Fr.", in *Ann. Univ. Fenn. Aboen.* I), because the only recognizable original species of *Tuburcinia* was *T. Orobanches* (a typical species of *Urocystis*) reduced *Urocystis* to a synonym of *Tuburcinia* Fr., thus necessitating a change of name for all the species of *Urocystis*, including several which attack important crops. Liro has been followed by the following authors: Sydow in *Ann. Mycol.* XXII, 237 and 290 (1924) and in *Ann. Mycol.* XXXIII, 233 (1935); Gäumann & Dodge, *Comparative Morphology of Fungi* (1928); Săvulesco, "Ustilaginales of Roumania", in *Anal. Inst. Cerc. agron. Roman.* VII, 347–430 (1935); Ciferri, *Flora Ital. Crypt.* (1938).

Ciferri also creates a new genus, *Ginanniella* Cif., for the species of *Tuburcinia* sensu Woron. which have no clear cortical cells, making the type species *G. Trientalis* (Berk. & Br.) Cif.

Recommendation. As the name *Urocystis* has long been used in floras, works on plant diseases, and in text-books, and as, since 1882, *Tuburcinia* has been used in a different sense, the replacement of *Urocystis* Rabenh. by *Tuburcinia* Fr. tends to create confusion and is therefore contrary to Art. 4 (2), which emphasizes that one of the essential aims of nomenclature is "to avoid or to reject the use of forms and names which may cause error or ambiguity or throw science into confusion". It is therefore recommended that *Urocystis* Rabenh. (type species *U. occulta* (Wallr.) Rabenh.) should be conserved against *Tuburcinia* Fr. (type species *T. Orobanches* (Mérat) Fr.).

Hypochnus Fr. *Syst. Mycol.* III, 289 (1829) emend. Schroet. *Pilz. Schles.* I, 415 (1889). Type: *H. serus* (Pers. *Mycol. Eur.* I, 151 sub *Thelephora* ex Fr. *Obs. Mycol.* II, 178 sub *Hypochno*) Karst. *Mycol. Fenn.* II, 320 versus *Lyomyces* Karst. *Rev. Mycol.* III, 23 (1881)

The above is the proposal as published in the appendix to the *International Rules*, 1935. The statement contains several inaccuracies. In the first place, *Hypochnus* in the sense proposed, with type *H. serus*, was first defined by Patouillard in *Hymen. d'Eur.* (1887), not by Schroeter. Secondly, the date of the part of *Pilz. Schles.* in which the name *Hypochnus* occurs is 1888, not 1889, and a third mistake is the citation of part II instead of III for Karsten's use of the name in *Mycol. Fenn.* The cumbersome method of citation of authors for the name *H. serus* is not necessary.

Lyomyces Karst. in *Rev. Mycol.* III, 23 (1881).

The name was applied by Karsten to hyaline-spored, resupinate Basidiomycetes, defined as having the receptacle membranaceous or fleshy, then flocculose and collapsing. The species included were *L. serus* (Pers.) Karst., *L. crustosus* (Pers.) Karst. and *L. papillosus* (Fr.) Karst. The two last were originally described as Hydnaceae and are now universally regarded as belonging to that group, hence *Lyomyces serus* (Pers.) Karst. must be regarded as the type of the name *Lyomyces*. In 1882 (*Hattsv.* II, 153), Karsten used the name in a slightly different sense. He there listed both *Hydnam crustosum* Pers. and *Grandinia papillosa* Fr. under the genus *Odontia* (Hydnaceae), and included *L. serus* (Pers.) Karst. in *Corticium*. On the other hand, he listed nine species under *Lyomyces*, most of which are now usually regarded as species of *Corticium*. The name has not been taken up by any other author; it was cited by Hennings in Engler & Prantl (*Nat. Pflanzenfam.* I, i**, 116 (1898)) and by Schroeter (*loc. cit.* p. 415) as a synonym under their conceptions of *Hypochnus*.

Hypochnus Fr. *Syst. Mycol.* III, 289 (1829).

The name *Hypochnus* was first used by Fries in *Obs. Mycol.* II, 278 (1818) for resupinate species defined as having a loose, tomentose texture. Of eight species included, two *H. serus* (Pers.) Fr. and *H. caeruleus* (Schrad.) Fr. have hyaline spores; the others for the most part have warted, more or less coloured spores. This publication of *Hypochnus* is, however, before the starting point (Fries, *Syst. Mycol.* I, (1821)) for the nomenclature of Basidiomycetes, and therefore not valid. Lindau & Sydow (*Thesaurus*) and Burt in his monograph of the Thelephoraceae of North America (*Ann. Mo. Bot. Gard.* III, 203 (1916)) refer to a second edition of the *Obs. Mycol.*, dated 1824, but Donk (1933) states that such an edition does not exist.† In the *Syst. Mycol.* the name *Hypochnus* does not appear until vol. III, p. 289 (1832), where it is attributed to Ehrenberg (1820). The genus here is not the same as that of the *Obs. Mycol.* Three species are cited, two of which were subsequently referred to lichens, and the third, *H. aureus* Fr. is a doubtful species, which was regarded by Fries himself as aberrant (see *Epicrisis*, 570 (1836)). *Hypochnus* of the *Syst. Mycol.* is therefore rightly referred as a synonym of the lichen genus *Chiodecton*

† See note, p. 229.

Ach. Unless, however, there is an 1824 edition of the *Obs. Mycol.*, this is the first valid publication of *Hypochnus*, and, as Donk has pointed out, the name cannot be used for fungi, and Karsten's subsequent emendation, which was adopted by Burt, is not valid.

In the *Epicrisis* (1836–38), Fries retained the conception of *Hypochnus* of the *Syst. Mycol.*, including four tropical lichens in his section "genuini". When he published the *Hym. Eur.* in 1874, these had been recognized as lichens, and he there reverted to the sense of 1818, using *Hypochnus*, however, only as a subgenus of *Corticium*.

Karsten (*Rev. Mycol.* III (1881)) recognized that *Hypochnus* in this sense included heterogeneous elements, and proposed limiting the name to those species having coloured, warted spores, which were in the majority in the 1818 publication. *Hypochnus* Fr. emend. Karst. has been adopted by Bresadola in *Ann. Mycol.* I (1903); Brinkmann, *Westfälische Pilze*; Burt in *Ann. Mo. Bot. Gard.* III, 203 (1916); Rea, *British Basidiomycetae* (1922). On the other hand, Patouillard (*loc. cit.*), Schroeter (*loc. cit.*), Hennings in Engler & Prantl, *Pflanzenfam.* I, i** (1898) used the name for the cobweb-like hyaline-spored species which are now usually referred to *Corticium* or to new genera based on basidial characters. Saccardo (*Syll. Fung.* VI) used *Hypochnus* in the old Friesian sense for species having a loose texture, whether with hyaline and smooth, or coloured and warted spores. Since Saccardo, and Engler & Prantl were the chief sources of information for pathologists, we find *Hypochnus* used in the older works on plant diseases, and even in some recent writings, for species such as *Corticium Solani*, etc.

Recommendation. Because the proposal to conserve *Hypochnus* with type *H. serus* (Pers.) Karst., a species universally referred to *Corticium*, does not accord with the views of any recent worker on resupinate Basidiomycetes, it is recommended that this proposal be rejected. As the name *Hypochnus* has been used in different senses and is a permanent source of confusion it should be placed on a list of *nomina ambigua*. If this is done, *Tomentella* Pat. (see next statement) becomes the valid name for the genus connoted by *Hypochnus* Fr. emend. Karst. (1881).

Tomentella Pat. (1887) versus *Hypochnus* Fr. emend. Karst. (1881)

Hypochnus Fr. *Syst. Mycol.* III, 289 (1829) emend. Karst. *Rev. Mycol.* III, 23 (1881).

The history of the generic name *Hypochnus* has been given fully under the previous proposal. Karsten's emendation defined a fairly homogeneous and easily recognizable genus. The name *Hypochnus* in this sense has been used by Bresadola (*loc. cit.*), Brinkmann, *Westfälische Bilze*, Rea (*loc. cit.*), Burt (*loc. cit.*) and Killermann in Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, VI (1928).

Tomentella Pat. *Hymen. d'Europe*, 154 (1887) ex Pers. *Obs. Mycol.* II, 18 (1799) ut subgen.

The name *Tomentella* first occurs in Persoon's *Obs. Mycol.* II, 18 (1799), where it is used in brackets, as a subgeneric name, for two species, *Corticium* (*Tomentella*) *ferrugineum* Pers., and *Corticium* (*Tomentella*) *chalybaeum* Pers. No diagnosis is given, but the species included have large coloured warted spores and are typical representatives of the genus subsequently circumscribed by Karsten under the name *Hypochnus*. Persoon's use of the name, in addition to being prior to the starting point for the nomenclature of Hymenomycetes (1821), is illegitimate because no diagnosis was provided. In 1887, however, Patouillard adopted the name as that of a genus, and provided a generic description. The name *Tomentella* has been used by Schroeter, *Pilz. Schles.* I (1888); Hennings in Engler & Prantl, *Nat. Pflanzenfam.* I, i**, 117 (1898); von Höhnel & Litschauer, *Beiträge zur Kenntnis der Corticeen* (1906–8); Bourdot & Galzin, *Hyménomycètes de France* (1928); Donk, *Revision der niederl. Homobasid.-Aphyllophor.* II (1933); Litschauer in Pilat, "Additamenta ad Floram Asiae Minoris" in *Bull. Soc. Mycol. Fr.* XLIX, 52 (1933); and by D. P. Rogers in *Univ. of Iowa Studies*, XVI, 175 (1934).

Recommendation. As the name *Hypochnus* is of doubtful validity as a fungal name, and has been used in different senses, it is recommended that it should be rejected altogether as a *nomen ambiguum*. If the use of the name *Hypochnus* in the *Syst. Mycol.* III (1829) is the first valid publication of the name, and this is a synonym of *Chiodecton* Ach., a genus of lichens, Karsten's emendation of *Hypochnus* in 1881 for a genus of fungi is not legitimate, and *Tomentella* Pat. (1887) is the valid name for species of resupinate Hymenomycetes with coloured, warted or aculeate spores. Should there be any doubt it is advisable to specify *Tomentella* Pat. as a *nomen genericum conservandum*, with type species *Tomentella ferruginea* (Pers.) Pat., one of the two original species mentioned by Persoon and one which is well known and easily recognized. (See note, p. 229.)

Poria (Fr.) Karst. (1881) emend. Sacc. (1888) versus *Physisporus* Gillet (1874–7)

The above is the proposal for conservation of the generic name *Poria* as given in the appendix to the *International Rules* 1935. Since *Poria vulgaris* (Fr.) Sacc. is specified as type, it seems clear that the intention of the proposer is to retain the name *Poria* either in the wide sense as given in Saccardo or for the pale-coloured species if the genus is split up. The author citations, however, are not correct. *Poria* in the wide sense was first delimited by Cooke in *Grevillea*, XIV, 109 (1886), and it was Cooke's arrangement which was followed by Saccardo. The citation should therefore read "emend. Cooke". The genus *Physisporus* was proposed by Chevalier in 1826, and was later adopted by Gillet.

Physisporus Chev. *Fl. Env. Paris*, ed. 1, 261 (1826) and ed. 2 (1836).

As proposed by Chevalier this genus included *Polyporus obliquus* (Pers.) Fr. and eight other species, among which were *P. medulla-panis* (Pers.) Fr., and *P. molluscus* (Pers.) Fr. It therefore included both white and brown species and was an earlier name for the genus in the wide sense as defined by Cooke in 1886. In this sense the name *Physisporus* was taken up by Gillet, *Champ. Fr.* (1874–7) and later in 1878, also by Costantin & Dufour, *Nouvelle Flore des Champignons* (undated). Karsten, in *Rev. Mycol.* III, 18 (1881), also used the name *Physisporus* but restricted it to the white or pale-coloured species, using *Poria* for the ferruginous species.

Poria (Pers.) Karst. in *Rev. Mycol.* III, 19 (1881) emend. Cooke in *Grevillea*, XIV, 109 (1886).

The first use of the name *Poria* as a generic name in works using binary nomenclature is by Persoon in *Roemer's Neues Mag. Bot.* I, 109 (1794), where three species were enumerated: *Poria medulla-panis* (Jacq.) Pers., *P. salicina* (Gmel.) Pers., and *P. fimbriata* Pers. Since the nomenclature of Hymenomycetes begins with Fries, *Syst. Mycol.* I (1821) this use of the name by Persoon cannot count for priority. It may, however, be of assistance in fixing the type species. Fries used the name *Poria* only in synonymy, in the *Syst. Mycol.*, but in *Nov. Symb.* (1851) he cited it as the name of a subgenus of *Polyporus*, including all the resupinate species, but without enumerating these by name. The first use of *Poria* as a generic name after 1821 appears to be by Karsten in *Rev. Mycol.* III, 19 (1881) and in *Symb. Mycol. Fenn.* VIII, 10 (1881), but he limited it to species having rust-brown pores and flesh, mentioning especially *P. ferruginosa* (Schrad.) Karst., *P. contigua* (Pers.) Karst., *P. rixosa* Karst. and *P. obliqua* (Pers.) Karst. Karsten continued this limitation in later works and at the same time used the name *Physisporus* Chev. for light-coloured species of resupinate Polyporaceae. The present generally-accepted usage of *Poria* for pale-coloured species dates from Cooke's rearrangement of the Polyporaceae in *Grevillea*, XIV (1886). This conception, besides being taken up in Saccardo's *Sylloge*, has been followed by most later European authors, such as Quélet, *Enchiridion* (1886); Massee, *British Fungus Flora*, I (1892); Rea, *British Basidiomycetae* (1922); Bourdot & Galzin, *Hymen. de France* (1927); Killermann in

Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, VI (1928); Konrad & Maubl. *Icon. Sel. Fung.* (1924–37); also in extra-European floras and monographs such as McAlpine, *Australian Fungi* (1895); Baxter, *Fap. Mich. Acad. Sci.* (1925); Butler & Bisby, *Fungi of India* (1931); Clements & Shear, *Genera of Fungi* (1931); Lowe, *Polyporaceae of New York State* (1933); Maneval, *List of Missouri Fungi* (1937); etc.

The greater number of species included in the genus *Poria* used in this wide sense belong to the light-coloured series. Some of them, as *P. Vaillantii*, are of economic importance as agents of timber decay. It is therefore necessary to consider carefully which species should be regarded as the type, or lectotype, of the generic name *Poria*. If the name is dated from its first valid use as a generic name by Karsten (1881), the type would have to be selected from one of the brown species, and the name could only be used for these, since the earlier and valid name for the genus, in the wide sense, is *Physisporus* Chev. If it is desired to conserve the name *Poria* in the sense indicated in this motion, it is necessary to cite the name from Cooke (1886), and to choose a type from among the white species. *P. vulgaris* (Fr.) Sacc., suggested by the proposer, has according to Bourdot & Galzin been applied to two different plants. *P. vaporaria* Pers., suggested by Clements & Shear, has also been much confused. It would seem preferable to choose *P. medulla-panis* Pers., which is a well-marked species, and which may be regarded as the historical type, since it is the only one of the three species of *Poria* originally named by Persoon which still remains in the genus.

Recommendation. Since *Poria* in the sense of Cooke and Saccardo has been so generally used in floras, and is known to workers in applied mycology everywhere as a name for certain well-known timber-destroying fungi, it seems desirable that the name should be conserved and the type chosen so that it shall apply to the white species even if the genus, in the wide sense, is divided. It is recommended that *Poria* (Pers.) Karst. emend. Cooke, with type *P. medulla-panis* Pers., should be conserved against *Physisporus* Chev.

Flammula (Fr.) Quél. (1872) versus *Flammula* Fourr. (1868), *Ryssospora* Fayod (1889), *Gymnopilus* Karst. (1879) and *Visculus* Earle (1909)

Flammula Fourr. in *Ann. Soc. Linn. Lyon*, II, 16 (1868), 324 (Ranunculaceae).

A genus founded on two species, *F. Lingua* Fourr. and *F. Ranunculus* Fourr. It is now universally reduced to synonymy under *Ranunculus*, and is not likely to be taken up by phanerogamists.

Flammula (Fr.) Quél. *Champ. Jura et Vosges*, I, 129 (1872) (Agaricaceae).

The name *Flammula*, first used as a subgenus of *Agaricus* by Fries, was given generic rank by Quélet. The genus as originally established appears to include heterogeneous elements, and various segregates have been proposed. While it is desirable to conserve a name so generally used in floras, monographs, and popular works, the important point is the selection of a suitable lectotype.

In Fries, *Syst. Mycol.* I (1821), the subgenus *Flammula* included three sections, *Pholioti* (six species), *Myxacii* (six species) and *Hebelomati* (three species). The section *Sapinei*, later added to *Flammula*, was at that time included in *Cortinarius*, and has recently been segregated as a genus (*Fulvidula* Romagnesi in *Rev. de. Mycol.* I, 209 (1936)). Hence the section *Sapinei* must be excluded when selecting a type species for the genus *Flammula*. Most of the common and well-known species of *Flammula* occur in the first two sections, *Pholioti* and *Myxacii*, proposed by Fries. The proposer of this motion suggests *F. astragalina* (Fr.) Quél. as type species; Clements & Shear and R. Singer suggest *F. flavida* (Schaeff.) Quél.; Romagnesi (*loc. cit.*) proposes *F. gummosa* (Lasch) Quél. as type species of *Flammula* (Fr.) sensu restr.

Ryssospora Fayod in *Ann. sci. nat.* VII, IX, 371 (1889).

As proposed by Fayod, the characters of this genus are not clear. Earle took up the name in 1909 as the equivalent of the series *Udae* of *Flammula*, which includes *F. flavida* (Schaeff.) Quél. If *F. flavida* be selected as the type of *Flammula*, *Ryssospora* in the sense of Earle must be conserved against. The name *Ryssospora* has not been used by any recent author.

Gymnopilus Karst. *Hattsv.* I, 400 (1879).

When proposed this genus included two species of *Flammula*, *F. picrea* (Pers.) Quél. and *F. liquiritiae* (Pers.) Quél. and a species of *Crepidotus*. It would thus appear to be synonymous with the section *Sapinei*, and Romagnesi cites *F. liquiritiae* (Pers.) Quél. as the type of his genus *Fulvidula*. Maire has adopted the name *Gymnopilus* for the genus in the wide sense, rejecting *Flammula*, but Konrad & Maublanc retain *Flammula*, thus following established usage.

Visculus Earle in *Bull. New York Bot. Gard.* V, 437 (1909).

The name *Visculus* was proposed as an alternative name for the later homonym *Flammula* Quél., the type suggested being *F. gummosa* (Lasch) Quél.

Recommendation. That since *Flammula* Fourr. is a synonym of *Ranunculus* and is not likely to be taken up, the name *Flammula* (Fr.) Quél. should be conserved against it. It appears, however, that at present the taxonomy of *Flammula* is not sufficiently clear to allow of a satisfactory choice of type. The most suitable appear to be either *F. flavida* (Schaeff.) Quél. or *F. gummosa* (Lasch) Quél.

Galera (Fr.) Quél. (1872) versus *Galera* Blume (1825) and *Conocybe* Fayod (1889)

Galera Blume, *Bijdr.* 415 (1825) (Orchidaceae).

A genus of Orchidaceae, including three species from Japan and Formosa. It is cited as a synonym under *Epipogum* S. G. Gmel. in the *Index Kewensis*, and is also reduced to synonymy in R. Schlechter, *Orchideologiae Sino-japonicae Prodromus* (1919) and in T. Makino & K. Nemoto, *Flora of Japan* (1931).

Galera (Fr.) Quél. *Champ. Jura et Vosges*, I, 103 (1872) (Agaricaceae).

Quélet first raised to generic rank the subgenus *Galera* Fr. (*Syst. Mycol.* I, 264 (1821)) of *Agaricus*. Fries originally had ten species classed in two sections, the characters of which were not defined. Later (*Hym. Eur.* (1874)) he had three sections, the largest of which was Conocephalae, including *Galera tenera*. When Quélet raised the subgenus to generic rank he also included three sections, but differently named and differing somewhat in circumscription. Roughly, however, his section Teneri, including *Galera tenera* and its allies, corresponded with the Conocephalae of Fries. The name *Galera*, in the sense of Fries and of Quélet, has been used in most European floras, including: Saccardo, *Syll. Fung.* VI, 860 (1887); Massee, *British Fungus Flora*, II (1893); Ricken, *Die Blätterpilze* (1915); Saccardo in *Flora Ital. Crypt.* (1916); Rea, *British Basidiomycetae* (1922); Bresadola, *Icon. Mycol.* Fasc. XVII (1931); Konrad & Maubl. *Icon. Sel. Fung.* (1924–37); Killermann in Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, VI (1928); also in Kauffman, *Agaricaceae of Michigan* (1918). In this wide sense the genus includes about fifty described species, some fifteen of which are European.

Karsten (*Hattsv.* I (1879)) segregated four species (*G. pityria*, *G. ovalis*, *G. ravida* and *G. mycenopsis*) as a new genus *Galerula*. Fayod (1889), publishing a new classification based on microscopic characters, retained the name *Galera* for a group of species chiefly included in Fries's section Bryogenae, while he proposed a new name *Conocybe* for *Galera tenera* and four other species. In his classification *Conocybe* is placed in the tribe Naucorieae, while *Galera* is placed in Tubarieae.

Earle (*Bull. New York Bot. Gard.* (1909)), rejecting *Galera* Quél. as a later homonym of *Galera* Blume, used *Conocybe* Fayod with the type *Galera tenera*, and made a new

name, *Galerina* Earle, for the section Bryogenae of Fries. These names, in an emended sense, have recently been taken up by Kühner in his monograph (*Le Genre Galera* (1935)) and adopted by R. Singer (*Ann. Mycol.* xxxiv (1936)).

Murrill in *North American Flora*, x (1917), in reuniting *Galera* sensu Karsten with *Galerula* Karst., rightly adopted the name *Galerula* for the combined genus, since the homonym *Galera* was rejected under the American Code, to which he adhered.

Lectotype. *Galera tenera* is suggested as the "standard species" or lectotype of *Galera* Quél., since it was one of the original species included by Fries in the subgenus *Galera*, was also included by Quélet, is a member of the largest section into which the genus was divided, and is common and well known.

Recommendation. As *Galera* Blume is not used by phanerogamists it is desirable to conserve against it the generic name *Galera* Quél. (type *Galera tenera* (Schaeff. ex Fr.) Quél.), which has been used by mycologists for over 65 years, and occurs in popular books on fungi as well as in scientific works. The name *Conocybe* Fayod must also be rejected, since it is a synonym of *Galera* Quél., as so defined, and would be the valid name if *Galera* be not conserved.

Tricholoma (Fr.) Quél. (1872) versus *Tricholoma* Benth. (1846), *Gyrophila* Quél. (1886) and *Monomyces* Earle (1909)

Tricholoma Benth. in DC. *Prodr.* x, 426 (1846) (Scrophulariaceae).

Tricholoma Benth. is given in the *Index Kewensis* as a synonym of *Glossostigma* Wight & Arn., an earlier name for this small genus. We are informed that the name *Tricholoma* is not likely to be taken up by phanerogamists.

Tricholoma Quél. *Champ. Jura et Vosges*, I, 76 (1872) (Agaricaceae).

In Fries, *Syst. Mycol.* I, 36 (1821) the name *Tricholoma* was used for a subgenus of *Agaricus*, consisting of forty-eight species arranged in four sections, *Limacina*, *Genuina*, *Spuria* and *Personata*. Later, in the *Monographia*, Fries added other sections and changed the name *Genuina* to *Flocculosa*. When Quélet raised the subgenus to generic rank he adopted the same circumscription and the same sections. As defined by Fries and by Quélet, on the basis of white spores, sinuate gills and fibrillose stem, the genus includes certain species or groups of species which in later years have been segregated as distinct genera. Such genera are *Cortinellus* Roze (1876) founded on *Tricholoma vaccinum* (Fr.) Quél., *Melanoleuca* Pat. (1900) which includes *T. melaleucum* (Fr.) Quél. and its allies, and *Rhodopaxillus* Maire (1913) including species such as *T. panaeolum* (Fr.) Quél. and *T. personatum* (Fr.) Quél. in which the spores are slightly pinkish in the mass. The important point in proposing the name *Tricholoma* for conservation is therefore the selection of type or lectotype. The name *Tricholoma* Quél. has been in use in most lists and floras in both European and other countries, whether in its original wide sense or in a restricted sense for species not removed to other genera. Among recent works it is only necessary to mention Rea, *British Basidiomycetae* (1922); Killermann in Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, VI (1928); Konrad & Maubl. *Icon. Sel. Fung.* (1924–37); R. Singer, "Das System der Agaricales" in *Ann. Mycol.* xxxiv (1936); etc.

It seems desirable that the type of the genus should be selected from one of the species which Fries originally included in his section *Genuina*.

T. sulphureum (Fr.) Quél., suggested by the proposer of this motion, is not suitable because (1) it was not originally included in the subgenus *Tricholoma*, and (2) in Fries's later works it does not appear in the section *Genuina* (or *Flocculosa*).

T. personatum (Fr.) Quél., proposed by Clements & Shear (1931) is not suitable because it is one of the species with rose-tinted spores which have been segregated in the genus *Rhodopaxillus* Maire.

T. equestre (Linn.) Quél., proposed by Singer (*loc. cit.*) is not a good choice, because although Fries originally included it in the section *Genuina* he later transferred it to *Limacina*.

It is undesirable to choose *T. vaccinum* because this was the type of *Cortinellus* Roze. Of the remaining species of the section *Genuina* there are four, *T. rutilans*, *T. imbricatum*, *T. terreum* and *T. columbetta*, which are distinct and well known and which might have equal claims to be chosen as the lectotype of *Tricholoma*. Of these, both *T. rutilans* and *T. terreum* date back to Schaeffer, and *T. rutilans* is here suggested as the most suitable lectotype, since it is common, well known, and there is no difficulty as to the specific epithet. (Under the present Rules the specific epithet of *T. terreum* should be changed to *myomyces*, which was the name used by Fries in *Syst. Mycol.* I.)

Cortinellus Roze (1876).

The name *Cortinellus* Roze, as taken up by Karsten in *Hattsv.* I, 24 (1879) to include the original type (*T. vaccinum*), *T. rutilans*, *T. terreum*, etc., is an exact synonym of the section *Genuina* of *Tricholoma*, and therefore of the name *Tricholoma* Quél. as here defined. Patouillard, however, and following him certain later authors (Singer, Konrad & Maublanc, Maire) have used the name *Cortinellus* for *Armillaria bulbigera* (A. & S.) Quél., which Patouillard said was the only species answering to Roze's definition of a "*Cortinarius* with white spores". In this sense Roze's type *T. vaccinum* and the other species included by Karsten are excluded from the genus. If it is desired to retain the name *Cortinellus* in this sense it will be necessary to conserve *Cortinellus* Roze sensu Pat. against *Cortinellus* Roze sensu Karst.

Gyrophila Quél. *Ench.* 9 (1886).

Gyrophila was proposed by Quélet to include both *Tricholoma* and species of *Armillaria*. As a name for species of *Tricholoma* it is antedated by *Cortinellus* Roze sensu Karst., but if *Cortinellus* Roze sensu Pat. be conserved against *Cortinellus* Roze sensu Karst., *Gyrophila* might become the valid name for *Tricholoma* Quél. if that name were not conserved.

Monomyces Earle in *Bull. New York Bot. Gard.* V, 442 (1909).

Earle proposed this name (adopted from Battarra (1755)) for the sections *Genuina*, *Rigida* and *Sericella* of *Tricholoma*, since under the provisions of the American Code he rejected the later homonym *Tricholoma* Quél. He cited *Cortinellus* Roze as a synonym. The name *Monomyces* Earle is therefore a direct synonym of *Tricholoma* (Fr.) Quél. as here defined, and must be rejected.

Recommendation. As *Tricholoma* Benth. is not used by phanerogamists and is not likely to be taken up, it is desirable to conserve against it the well known name *Tricholoma* (Fr.) Quél., which occurs in nearly all works dealing with Agaricaceae, except those of strict adherents of the American Code, such as Earle (1909) and Murrill in the *North American Flora*. The lectotype *T. rutilans* (Schaeff. ex Fr.) Quél. is suggested. The names *Gyrophila* Quél., *Cortinellus* Roze sensu Karst. and *Monomyces* Earle should also be rejected.

Volvaria (Fr.) Quél. (1872) versus *Volvaria* DC. (1805) and *Pseudofarinaceus* Earle (1909)

Volvaria DC. apud Lam. & DC. *Fl. Franç.* ed. 3, II, 373 (1805) (Lichenes).

Under this generic name De Candolle enumerated three species of lichens, which are now classed in three different genera. The name thus appears to be a *nomen ambiguum*, and probably for this reason has not been used by lichenologists since 1859. In Zahlbruckner, *Cat. Lich. Univ.* II, 683 (1924), it is cited as a synonym of *Petractis* Fr. (*Summ. Veg. Scand.* 120 (1846)).

Volvaria (Fr.) Quél. *Champ. Jura et Vosges*, I, 62 (1872) (Agaricaceae).

Volvaria, a subgenus of Agaricus in Fries, *Syst. Mycol.* I, 277 (1821), was first raised to generic rank by Quélet (*loc. cit.*). The name has been used in most floras and lists of fungi for nearly seventy years, as for instance Karsten, *Hattsv.* I (1879);

Saccardo, *Syll. Fung.* v (1887); Massee, *British Fungus Flora*, II (1893); Costantin & Dufour, *Nouvelle Flore des Champignons*; Ricken, *Die Blätterpilze* (1915); Saccardo in *Flora Ital. Crypt., Hymeniales* (1916); Rea, *British Basidiomycetae* (1922); Bresadola, *Icon. Mycol.*, fasc. XI (1929); Konrad & Maubl. *Icon. Sel. Fung.* (1924–37); Killermann in Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, VI (1928); also in Kauffman, *Agaricaceae of Michigan* (1918); Petch, "Ceylon Pink-spored Agarics" in *Ann. Roy. Bot. Gard. Peradeniya* (1924); Heyne, *Nutt. Plant. Ned. Ind.* (1927); etc. The genus contains about thirty described species, occurring particularly in warmer regions. One species, *V. volvacea* (Bull.) Quél. is a well-known edible form and is cultivated in many tropical countries.

Although not listed by Quélet at the time he first raised the name *Volvaria* to generic rank (1872), the historic type would appear to be *Volvaria volvacea* (Bull.) Quél. It was originally described by Bulliard, was included by Fries in the subgenus *Volvaria* of *Agaricus* in 1821, was one of two species included in Persoon's *Synopsis* (1801), and was the first species mentioned by Roussel (*Fl. Calvados* (1806)) in describing his genus *Volvarius*. Its specific epithet suggests the genus.

Pseudofarinaceus Earle in *Bull. New York Bot. Gard.* V (1909).

This name was taken up by Earle from Battarra (1755). Its use for *Volvaria* is, however, invalidated by its previous use by O. Kuntze (*Rev. Gen. Pl.* II, 867 (1891)) for *Amanitopsis* Roze. If *Volvaria* Quél. be not conserved the valid name for this genus is *Volvariopsis* Murr. (*Mycologia*, III, 280 (1911)). Neither name has been taken up by any other author.

Recommendation. Since *Volvaria* DC. is not now used by lichenologists and is unlikely to be taken up, as being a *nomen ambiguum*, it is recommended that the name *Volvaria* Quél. be conserved for the well-known fungal genus, which includes edible species. As lectotype *Volvaria volvacea* (Bull.) Quél. is suggested, rather than *V. bombycina*, given by the framer of this proposal, or *V. speciosa*, proposed by Clements & Shear (1931) and by Singer (1936), since *V. volvacea* appears to be the historic type. The name *Volvariopsis* Murr. is to be rejected, since this is the valid name if *Volvaria* (Fr.) Quél. be not conserved.

Tubercularia Fr. (1829) versus *Tubercularia* Wiggers (1780) and *Knyaria* O. Kuntze (1891)

Tubercularia Wiggers, *Fl. Hols.* 87 (1780) (Lichenes).

The name *Tubercularia* as a lichen genus was accepted by Baumgarten, *Flora Lipsiensis*, 583 (1790); Wibel, *Prin. fl. Wertheimensis*, 323 (1799); O. Kuntze, *Rev. Gen. Pl.* II, 876 (1891). It was rejected in favour of *Baeomyces* Pers. by Acharius, *Lichenogr. Suec. Prodr.* 81 (1798); Guillemin, *Dict. Cl. d'hist. nat.* 418 (1830); Th. Fries, *Lichenogr. Scand.* II, 329 (1874) (but states in a note that according to strict priority *Tubercularia* Wigg. should be used); Zahlbruckner in *Hedwigia*, 38 (1892); Wainio, *Lichenog. Fennica*, II, 3 (1922); Zahlbruckner, *Cat. Lich. Univ.* IV, 407 (1926–7).

Tubercularia Tode ex Fr. *Syst. Mycol.* III, 463 (1829) (Hyphomycetes).

The genus *Tubercularia* was proposed by Tode and occurs in various mycological authors before Fries. Since the publication of Fries's *Systema* it has been accepted by Guillemin, *Dict. Cl. d'hist. nat.* 418 (1830); Fries, *Summ. Veg. Scand.* 361 (1846); Fuckel, *Symb. Mycol.* 366 (1869); Cooke, *Handbook of Brit. Fung.* II, 557 (1871); Karsten, *Mycol. Fenn.* II, 213 (1873); Saccardo, *Syll. Fung.* IV, 638 (1886); Cooke, *Australian Fungi*, 385 (1892); Lindau in Rabenhorst, *Kryptogamen-Fl.* I, IX, 420 (1910); Gaümann & Dodge, *Comp. Morph. Fungi* (1928); Clements & Shear, *Genera of Fungi*, 221 (1931); Migula, *Kryptogamen-Fl. Deutschl.* III, IV, 472 (1931–4); etc. Lectotype: *Tubercularia vulgaris* Fr.

Knyaria O. Kuntze, *Rev. Gen. Pl.* II, 855 (1891).

This name, proposed by Kuntze as an alternative name for the later homonym *Tubercularia* Fr., has not been adopted anywhere.

Recommendation. As *Tubercularia* Wiggers was out of use for one hundred years until Kuntze re-established it in 1891, since when it has not been re-adopted, it is recommended that the name *Tubercularia* Fr., applied to a well-known genus of fungi of economic importance, should be conserved against it. The alternative name *Knyaria* O. Kuntze should be rejected.

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Note. Since the above article was sent to press, a paper has appeared by D. P. Rogers entitled "The Genus Hypochnus and Fries's Observations" (*Mycologia*, XXXI, 297 (1939)) in which he records the existence of two copies of Fries's *Obs. Mycol.*, having a title-page with the date 1824. In both, the text appears to have been printed from the same type as the first edition, and the title-page for the second part remains with the date 1818, as in the original edition. The only difference is the addition of another title-page, printed on different paper and with the date 1824, in the front of the volume. Dr Rogers considers that this is not a genuine second edition, and that it may be disregarded. That view is open to question, but the existence of such an edition does not affect our opinion that the name *Hypochnus* should be rejected entirely.

If the genus *Caldesiella* Sacc. be united with *Tomentella* Pat., as is considered necessary by Dr Rogers (*loc. cit.* p. 305), then, as he suggests, the name *Caldesiella* Sacc. should be specified as a *nomen rejiciendum* under the proposal to conserve *Tomentella* Pat.

REVIEW

The Genus Septobasidium. By JOHN N. COUCH. Pp. ix and 480 (text pp. 302), 114 plates, 60 text-figures. The University of North Carolina Press, Chapel Hill, North Carolina. Published 16 July 1938. Price $5.

Thirteen years ago, in 1926, Dr Couch started work on the taxonomy of the genus *Septobasidium*. At that time about seventy-five species had been described, but very little was known about them. With the advantage of having abundant material of one species, *S. Burtii*, at hand, Dr Couch undertook a thorough investigation of the relation existing between these fungi and scale-insects. That scale-insects are associated with species of *Septobasidium* had been noticed by von Höhnel & Litschauer in 1907, and these authors suggested that the relationship might be either parasitism or saprophytism, or some more complex symbiotic relationship. Other authors have paid attention to this problem in connexion with *Septobasidium*, but it is to Dr Couch that science is indebted for a series of papers, proving by careful examination and experiment, the existence here of a most intricate and unusual form of symbiosis.

The present work gives a full illustrated account of the biology of *Septobasidium*, which now appears to be fairly thoroughly understood. Briefly, while the fungus is parasitic on some of the scale-insects, and in fact cannot live without them, it, at the same time, provides shelter and protection for healthy scale-insects which feed on the bark beneath. In some species of *Septobasidium* the partnership is so highly developed that the fungus body provides beforehand small chambers which act as traps for the young scale-insects crawling over the surface after birth.

Thus the view that species of *Septobasidium* may be beneficial in reducing attack by scale-insects is shown to be erroneous. Actually, the fungus-scale combination is often very injurious, and may cause the death of branches or even of whole trees. Sprays have been found to be useless, and it is suggested that the most effective method of control is likely to be the cutting out of infected branches during the dormant season.

Following the two chapters on the fungus-insect relationships and on pathological considerations, there is a section dealing with geographical distribution, host plants and insects concerned, and a discussion of the taxonomy of the genus. After careful study of all available material the author now considers that it is not advisable to propose any subdivisions of the genus, since the groups overlap in all characters except those of basidia and probasidia. He therefore rejects the sections *Typicae* and *Gausapia* proposed by Patouillard and the genus *Noackia* Pat., also the genera *Ordonia* and *Mohortia* of Raciborski and his own subgenus *Unisporum* proposed in 1929. In a discussion of relationships Couch expresses the view that the genus *Septobasidium* represents a separate order ranking with the Auriculariales, Uredinales and Ustilaginales.

The main part of the volume is occupied by careful descriptions of species, preceded by a key. 163 named species and several varieties are described. In addition, there are descriptions of two hybrid forms. Fifty species are described for the first time, and four new varieties. None of these, however, is provided with a Latin diagnosis. Three species are listed as incompletely known and three (*S. album* Burt, *S. cinnabarinum* Syd. and *S. Polypodii* Couch) are excluded from the genus.

Finally, there is a very full list of literature, and numerous fine black-and-white

plates, showing photographs of macroscopic features, and careful drawings of microscopic structure.

Dr Couch is to be congratulated on the careful and thorough investigations which have led to the production of this fine monograph. The work is interesting alike to biologists, systematists and pathologists. The volume is well produced, with clear print and headings. The pagination is a little unusual in that it extends to the plates and their descriptive text. Thus, while the text and literature finishes on p. 302, the plates and their facing letterpress extend the pages to 475. Finally there are four pages of the index.

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